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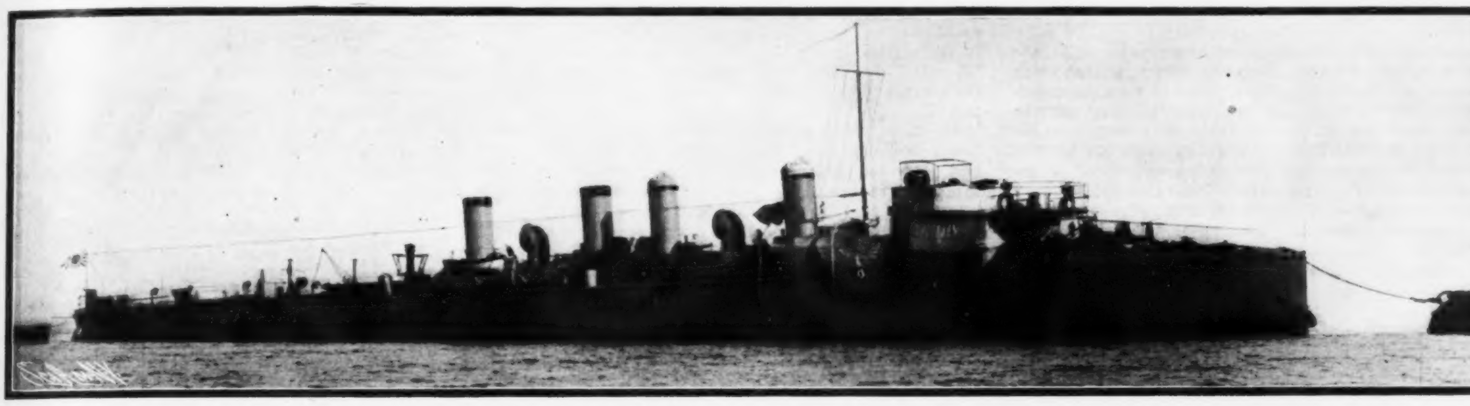
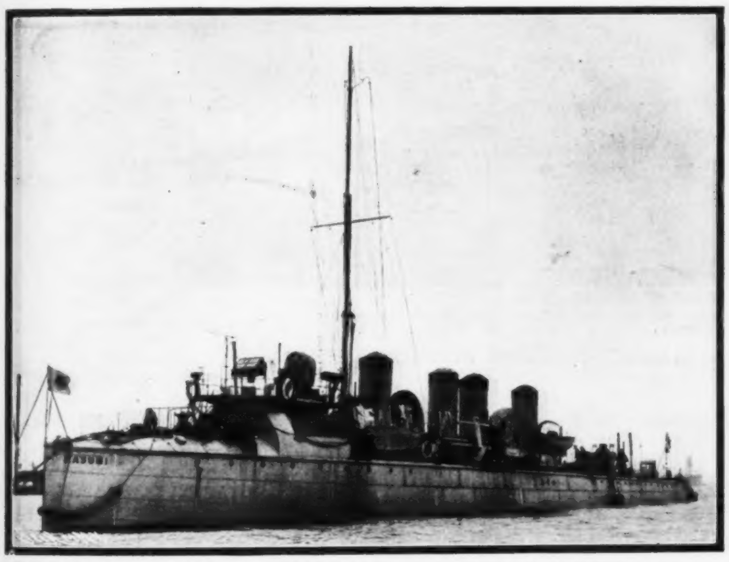


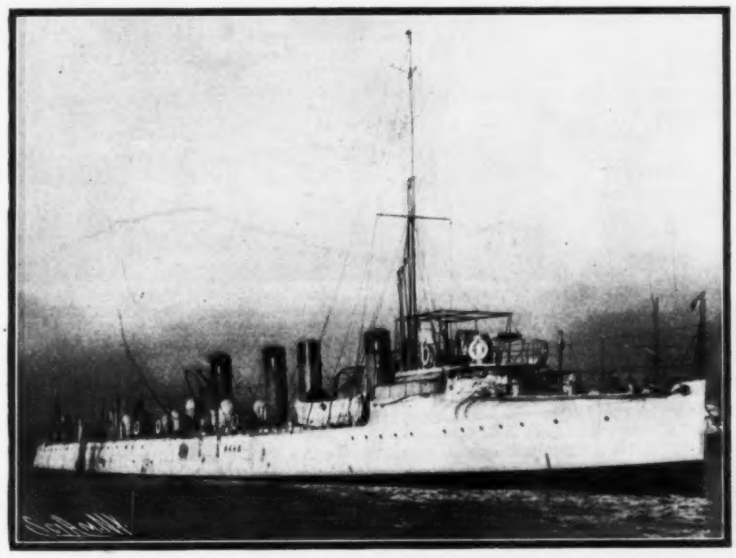
Length, 220 feet. Beam, 20.6 feet. Draft, 9.6 feet. Displacement, 360 tons. Speed, 31 to 31.4 knots. Armament: One 3-inch; five 6-pounders; two 18-inch torpedo tubes. Builder, Yarrow. Date, 1899.

"SAZANAMI." CLASS OF FOUR DESTROYERS.



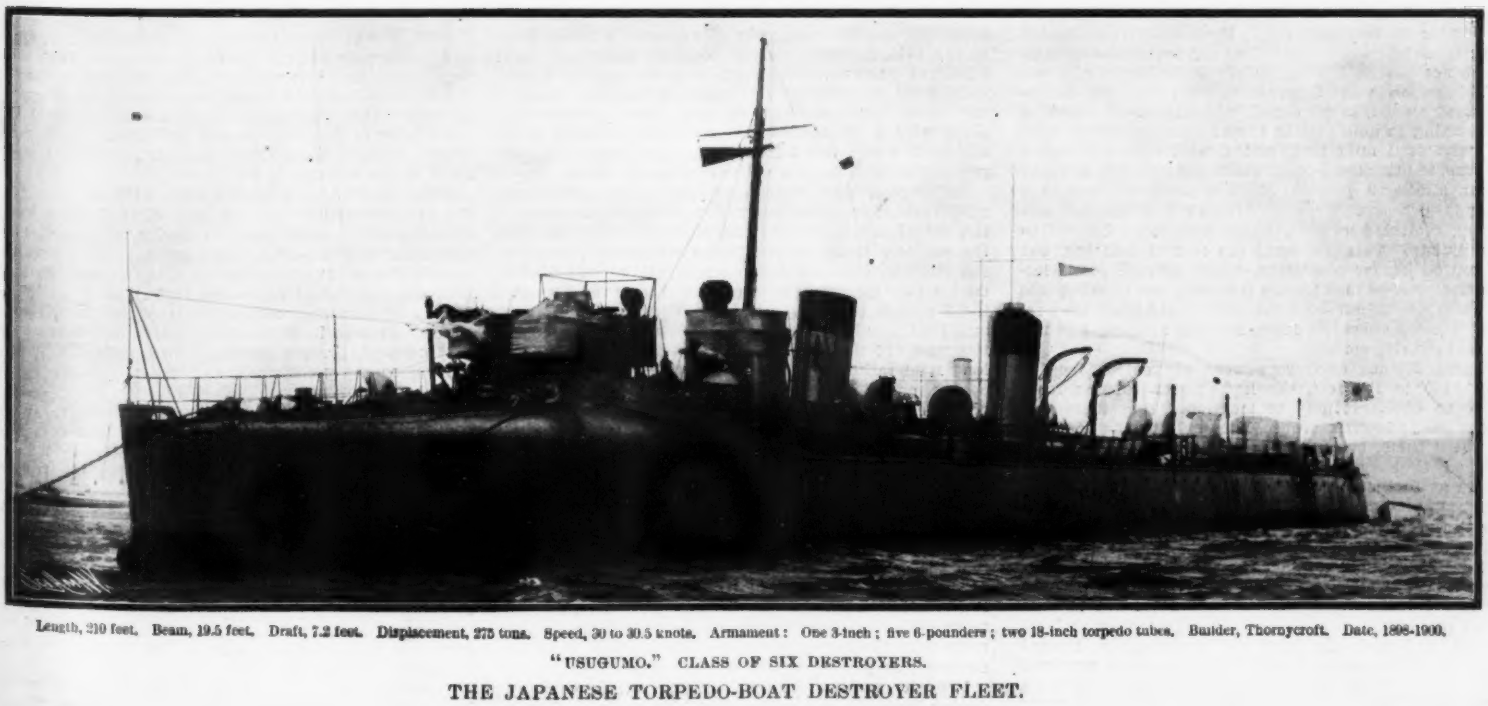
Length, 220 feet. Beam, 20.6 feet. Draft, 9.6 feet. Displacement, 360 tons. Speed, 31 knots. Armament: One 3-inch; five 6-pounders; two 18-inch torpedo tubes. Builder, Yarrow. Date, 1902.

"KASUMI." ALSO "KATSUKI."



Length, 216.7 feet. Beam, 20.7 feet. Draft, 8.3 feet. Displacement, 300 tons. Speed, 31 knots. Armament; One 3-inch; five 6-pounders; two 18-inch torpedo tubes. Builder, Thornycroft. Date, 1901-1902.

"SHIRAKUMO." ALSO "ASASHIO."



Length, 210 feet. Beam, 19.5 feet. Draft, 7.2 feet. Displacement, 275 tons. Speed, 30 to 30.5 knots. Armament: One 3-inch; five 6-pounders; two 18-inch torpedo tubes. Builder, Thornycroft. Date, 1898-1900.

"USUGUMO." CLASS OF SIX DESTROYERS.

THE JAPANESE TORPEDO-BOAT DESTROYER FLEET.

[Concluded from Supplement No. 1577, page 25263.]

THE DEVELOPMENT OF THE TORPEDO-BOAT DESTROYER.*

By W. J. Harding.

About this time also the "torpedo-boat destroyer" was evolved. Practically these destroyers were given just double the power of the latest torpedo boats in being. The hulls were built round them with due regard to the armament and the weight to be carried on trial, and also, of course, with due regard to the fact that they would be expected to be more sea-going. The draft was restricted to 5 feet, giving immunity from destruction by Whitehead torpedoes, which are erratic and inclined to "porpoising" if set to run at 5 feet depth or thereabout. They were armed with guns and Whiteheads, and so were calculated to destroy not only torpedo boats but battleships. This batch of destroyers, originally confined to Yarrow, Thornycroft, and White, was afterward spread all over the country. They are fairly well known to most engineers. These expanded an industry which required high technical knowledge and superior handicraft.

Observers of the building of these hulls will note that with the very thin plates as used it is absolutely necessary to manipulate those plates to give the requisite strength to resist any alteration of form. A five pound plate—that is, ⅛ inch thick—is a very limp object when received from the cogging mills, but after it has passed the leveling slab and been leveled it becomes very stiff; and its actual tensile strength is not in any way altered, while its strength to resist bending is very much increased, the leveling or "planishing" rendering the plate extremely stiff; and it is this knowledge of building among the workmen employed which is greater power and with a much greater coal consumption also gave the same speed of 27 knots; and though it may be asserted that the large vessel has advantages over the smaller one, primarily in the matter of habitability, I would put it that the vessel doing the work on the least displacement and with least coal consumption is certainly a triumph of brains, if nothing else. I also think that such a vessel should initially cost less than a larger one—certainly she should cost less for maintenance.

One important improvement introduced by Mr. White, prior to the year 1883, is a feature in all subsequent torpedo boats and all destroyers. This is the cutting away of the dead wood at the stern, thereby securing a maneuvering power that would otherwise be scarcely possible, coupled with a more efficient feeding of the propellers so essential to high speed. It is well known that from 1891 to 1896 the trials of the 27-knot destroyers were chronicled in the newspapers, and each seemed to go one better than the other.

In the matter of speed the highest on the measured mile was given by the "Boxer," by Thornycroft, the speed obtained being 29.1 knots with 4,490 horse-power. In the matter of coal consumption, the lowest was the "Hornet," by Yarrow & Company; she burned 9,322 pounds per hour, giving 27.6 knots, the highest burning 17,122 pounds per hour, giving 27.4 knots.

All these trials were full of very interesting incidents, and one thing they taught was that the very best material, and certainly the very best workmanship, was indispensable, coupled, of course, with the most talented brains in the drawing office. For the "spoke-shaving" was such that between success and failure was almost at times just the thickness of a sheet of paper. In the matter of machinery trials ship was required, and also showing how negligent workmanship cost many golden sovereigns to the shipbuilders. Boilers, engines, condensers, shafting, and screw propellers, all gave little troubles, and all gave valuable pointers for improvement in the future.

As regards the boilers, it was proved that the locomotive boilers gave excellent results up to a certain grade of coal burning, and at slow burning they were very economical, but the tube ends could not be depended on to remain tight. These troubles were not experienced in water-tube boilers, which were of various systems, some with straight and some with curved tubes. Practically all showed their superiority over any type of locomotive boiler which had hitherto been used, when forced to the utmost extent of their coal-burning capacities. Nevertheless, the locomotive boiler gave 1 horse-power for 1.33 square feet of heating surface, as against a maximum of 2.58 square feet in a water-tube boiler.

Usually incidents in the engine room were due to inefficient lubrication. It is generally well known that the oiling was supplemented by men with syringes, and there was no stint of oil. So large a quantity was used, that, if named, it might cause a great deal of horror to those who are wont to be economical in the engine room. I can, perhaps, mention only that in a foreign destroyer, modeled something after the English pattern, the engine-room department is credited with having used 450 gallons of oil in three hours, so that at least they must have been pretty attentive to the oiling. Our records do not chronicle such a high consumption.

If the white metal of the crank-head at any time ran, it was very advisable to stop the engine dead, as otherwise unpleasant consequences ensued. Generally

Length, 245 feet. Breadth, 23 feet, 7¼ inches. Draft, 6 feet, 6 inches. Displacement, 420 tons. Contract speed, 29 knots. Bunker capacity, 139 tons
Armament: Two long 18-inch Whitehead torpedo tubes; two 3-inch R. F. guns; five 6-pounders. Complement, 73.

TORPEDO-BOAT DESTROYER "PERRY"—"BAINBRIDGE." CLASS OF SIXTEEN VESSELS.

LONGITUDINAL SECTION, SHOWING INTERNAL ARRANGEMENTS OF TORPEDO-BOAT DESTROYERS.

noticeable in various vessels, those built from longer experience being certainly stiffer and better vessels than those not having the benefit of that experience.

This paper is not intended to enter into the dimensions of scantlings employed, but perhaps it would be interesting to note that in the 27-knot destroyers built of galvanized mild steel plates, with tensile strength 30 tons, the thickness of garboard strake is 6½ pounds; sheer strake, 9 pounds; deck plating, 6½ and 8½ pounds per square foot. Afterward a harder and stronger steel was used, which was more difficult to manipulate. This increased the cost of building, but permitted lighter scantlings, comparatively. This latter steel was 40 tons tensile strength. Its riveting was much more difficult with the hard rivets used; they required more knocking down, and the riveting was not so comely and smooth.

These 27-knot destroyers were of various lengths from 180 to 190 feet, the horse-power varying from 3,700 to 4,800. It may be mentioned that there was great public interest aroused, not only by the ordering of these boats, but from the fact that some men who seemed to have knowledge actually expressed their views as to the speed being unobtainable; and in one case simultaneously with such assertions that the speed was not obtainable there came the actual news that the "Havock," by Yarrow & Company, the first of the destroyers, had obtained a speed of 26.2 knots. This vessel (length 180 feet, beam 18 feet 6 inches, depth 10 feet 6 inches, and displacement 240 tons) showed what could be done with least displacement, with least power, and with the least coal consumption, toward carrying the armament required at the speed required. The larger vessels carrying the same armament with

* Read before the Institute of Marine Engineers, England.

numerous incidents might be mentioned. I should like to say this, having observed some of the trials—and I am not alone in my opinion—that the way in which youngsters, apprentices, and young journeymen, tackled the duties which were placed upon them, and tackled them with a knowledge that occasionally there were accidents which might produce maiming, was certainly good to observe from a national point of view.

Better pens than mine have told of the fair-haired public school boys and others doing their duties among the machinery in a most laudable manner, including the son of a belted knight in the stokehold oiling the fan engines, and certainly covered at the end of the trial with a coating of oil and coal dust perhaps weighing 2 pounds to the square foot of flesh and clothing; and I might also mention one case of several apprentics who did the coal trimming in the bunkers for a long trial rather than forego the trial by waiting for coal trimmers who did not turn up. So much for the personal element.

It was my great honor to take Mr. Rudyard Kipling into the engine room of a Thornycroft destroyer on trial. He seemed to be much impressed by seeing engines with 18-inch stroke doing 400 revolutions in an apparently small space, the eight connecting rods each making 800 swings a minute, faster than the eye could follow. He said that he had come to the conclusion that the youth who wished to become an engineer was prompted not so much by love of pelf, but from seeing the creations of engineers do such work as this and to be identified with it. He also compared the engine room with the five hundred bewilderments of ill-livers deceased, as preached in some tenets.

I might mention many incidents which occurred during these trials, showing that high-grade workman- it may be said that all oiling arrangements were made with a view to keeping oil in the journal. That is to say, the oil channels were stopped short at the ends of the bearings, and the liners between the brasses were in some cases made to fit close, if not touching the crank pins or journals, so that the oil could all be retained between the rubbing surfaces, and only weep away at the ends.

Some trouble was experienced with surface condensers, principally in the matter of split tubes, some splitting before, some splitting during, and some splitting after a trial—as a consequence producing boiler trouble from brackish feed. I think it may be said that the troubles of water-tube boilers arise primarily from faulty surface condensers, and had satisfactory condensers been in vogue when water-tube boilers were first adopted, there is no doubt that much public discussion on the great water-tube boiler question would have been avoided.

The form of surface condenser used in destroyers is well known, a few having double flow of circulating water and the majority having a single flow. My opinion is that those having the double flow—that is, having short tubes—have given less trouble than those having the single flow with long tubes. Even the most hypercritical inspections and testings of condenser tubes before building the condenser failed to obviate all trouble. There is such a little difference between those tubes which act well and those which act badly that it can hardly be detected. Toughness, combined with requisite hardness, is what was aimed at, and in some cases hardness verged on to brittleness, and brittle tubes became split.

The quality of the material may be fairly well tested by taking a short piece and cracking it in a vise. Those

which compress to a certain limit and crack in only two places give better working than those that compress and crack in three places. A good, tough tube of the required hardness should be capable of being flattened with water pressure test of 300 pounds inside of them without fracture, and pieces flattened in the vise should bear a certain amount of flattening without fracture, and the alteration in dimensions at fracture should point as to the quality of the tubes. It is well known that in the larger ships of His Majesty's navy, it has become a practice to fit two condensers to each engine, so that if one becomes defective and gives salt feed it may be shut off and rectified, the remaining condenser giving a fair amount of power, though reduced.

I look forward to the time when the Hall surface condenser will be abolished, and I have had an opportunity of seeing an invention toward this end. By the kindness of Messrs. Caird and Rayner, I have viewed a new type of condenser, which will enable condensers being built in groups each of 1,000 horse-power, and each and every one of these may be disconnected at any time for examination and repair, whereas with the present surface condensers examination of the thousands of square feet of internal and external surfaces of the tubes is almost an impossible operation. With the condenser of Caird and Rayner, I note that such may be taken apart in a few minutes, and the whole of the internal and external surfaces of the cooling area examined, corrosion noted (if any), and the surfaces cleaned and rendered efficient.

As well as split tubes in the torpedo-boat destroyer's condensers, we have had occasionally ferrule slackening, due, no doubt, to vibration. This was overcome in some cases by the invention of the Thornycroft ferrule. Of all the systems, however, I prefer the Yarrow system, in which the tube goes right through the ferrule, and has a small wire guard to prevent slackening of ferrule, and it has the great advantage of giving an unimpeded flow of a full bore of water through the tube. The ordinary ferrule now in use would not give this, as there must be some eddying at the entrance of the tube.

Occasionally there were twisted shafts, about which there were many opinions, some holding that the shafts were not strong enough, and some holding that the longitudinal vibration of the vessel tended to seize the shafting in the bearings, and so produced twisting.

Most valuable lessons in fatigue of metal were learned. Stresses which, if once applied, would give no indication of ultimate fracture, were found to produce fracture after thousands of such stresses. These were principally by bending. I may mention that in bolts with reduced shanks, which were supposed to stretch a lot before breaking, I never saw any such stretching, the bolts generally fracturing near the end of the screw thread. Had there been such stretch of material, some disasters might have been averted.

But above all, those trials gave most valuable lessons in screw propellers. It had been customary in torpedo boats and prior boats to make propellers of forged steel, but the substitution of manganese bronze propellers of practically the same dimensions gave the then marvelous result of an increase of speed of about two knots. At 384 revolutions per minute the forged steel propeller gave 24¾ knots; the manganese bronze propeller at the same revolutions gave 27 knots in the same vessel at the same draft.

Other items as to the various ratios to be used—namely, the ratio of pitch to diameter, and the area of the blade as compared with the area of the propeller disk—also became apparent, showing the direction in which improvement might be effected, as well as indicating other suitable dimensions. Generally, the knowledge gleaned was that each time the propeller was fined there was a gain, and each time the propeller was decreased in diameter, retaining the same pitch, there was a loss. To a certain ratio the area of the blade could be increased with advantage, provided the engine would turn the propeller round. Practically, whenever the slip was decreased by fining the propeller or by fining and increasing its diameter, or perhaps by fining, increasing its diameter, and adding more blade area, there was an improvement not only in speed, but in the coal bill.

Vibration was found to be modified by the propeller used, by the position of the blades with respect to the cranks, and by pitch deviations in each blade. The speed of no slip was important.

These experiments showed that if only the indicated horse-power were required, the propeller could be fitted which would give perhaps 20 per cent more horse-power than an ordinary propeller. If the speed were required, a very different propeller would be adopted; but if speed coupled with a small coal bill were required, the propeller between these two would give the best results. Also that the proportions of the propeller influenced the coal per indicated horse-power, the coal per indicated horse-power propeller lacking in propulsive effect. The least immersion of the propellers gave the best results both in speed and coal bills; and the distance apart of twin-screw propellers was of moment.

I may give comparative instances of propellers showing how improvement was given: (*a*) diameter increased 4 per cent, area increased 19 per cent, pitch not altered, the coal bill was decreased 27 per cent at equal high speeds; (*b*) pitch fined 6 per cent, no other alterations, gave the same high speed with 10 per cent less indicated horse-power, and 17¾ per cent less coal bill, (*c*) diameter increased 2 per cent, pitch fined 9 per cent, gave ¾ knot more speed, and coal bill decreased 40 per cent at the same high speed obtained by the first propeller.

I suggest that the torpedo-boat destroyer experiments might be regarded as model experiments on a very large scale, of which the expense was borne by the contractors, and the result is that many larger ships, both naval and mercantile, are now having much more efficient propellers fitted—perhaps from this experience. The words of Sir W. H. White, uttered twenty-one years ago, were prophetic: "In these torpedo vessels we have no doubt the pioneers of future navigation at higher speeds than have ever been attained."

The load carried on these 27-knot destroyers was 30 tons. This was a task heavier than had hitherto been the practice in any navies.

In this matter of propellers it will thus be seen that when 27-knot destroyers are loaded down to their war-service draft their trial-trip propellers are practically unsuited for that draft, and the loss of speed which ensues consequent on the choking of the propellers due to increased draft and displacement, is noticeable, and gives some disappointment.

I am of opinion, however, that all 27-knot destroyers could even now obtain better sea-speeds if they could be fitted with propellers different from their original ones. But this is a very complicated question, as it will be seen that a propeller which may enable the engines to do their speed, we will say, of 400 revolutions a minute with a fully loaded destroyer, may let those engines run away in an undesirable manner if she be lightened to nearly empty bunkers and magazines. New deep-draft propellers provided by the original constructors of the vessels would doubtless give increased speed with lessened coal bills, which would soon pay for this small outlay.

Those 27-knot boats gave an indication that the depth of water in which measured mile trials were run was of very great moment in results obtained. Practically in the same vessel run on two different measured miles, one locality would require fewer revolutions per knot, and the engine not so much loaded as the other. In this respect there is no doubt the measured mile at Wemyss Bay is the best. Those destroyers which obtained their speed in shallow water have generally given better sea results than those which obtained their speed in deep water.

Experience gained in the 27-knot destroyers was of great use when faster ones of 30-knot speed were required.

During the construction of the 27-knot destroyers Messrs. Yarrow & Company produced the "Sokol," a destroyer for the Russian navy. This vessel, 190 feet long by 18 feet 6 inches beam, obtained a speed of 29¾ knots in the shallow water of the Maplin Sands measured mile, and so proved herself superior to all British destroyers. Probably if she had run at Wemyss Bay she would have approached 31 knots. She was the precursor and pattern of a large number constructed in Russian yards.

The terms of the trials for the 30-knot destroyers were very much amplified, for whereas in the former 27-knot destroyers there were no reserves of coal consumption, in these it was intended that 2½ pounds per indicated horse-power per hour should be a standard. This was much less than the average of the former 27-knot destroyers. Messrs. Thornycroft & Company obtained the first record for 30 knots in a British naval vessel at the Maplin Sands in the "Desperate" in April, 1896. The vessel was loaded as per contract, and ran this trial in a stiff gale with all wind resistances, boats, etc., in place. Various contractors throughout the kingdom followed on, and in most cases fulfilled the contract without very much exertion. There were, as before, a few incidents arising from unforeseen circumstances, but take it all round the 30-knot destroyer gave less trouble than prior ones.

Two other destroyers of higher speeds were also produced, the "Albatross" by Thornycroft, and the "Express" by Laird. The former obtained a speed of 31½ knots with indicated horse-power of 7,700. This was at the Maplin Sands, where the drag of water, due to shallowness, became very apparent. The latter was tried at Wemyss Bay.

The 30-knot destroyers were followed by a reaction in favor of stronger vessels, now known as the river class. These vessels are of about 550 tons displacement, 200 to 230 feet long, and horse-power 7,500. They are much more costly than the 30-knot destroyers, and though their speed of 25½ knots was obtained in deep water, I am of opinion that, as before mentioned in my remarks, if the 30-knot destroyers had different propellers fitted they would outrace all the rivers at war-service lading with a smaller coal bill.

The accompanying table, taken from a parliamentary return, gives information of the river class.

I should mention that the latest torpedo boats, Nos. 89 to 117, were tried at their deep-sea draft, and obtained speeds of 25 knots, with an average horse-power of about 3,000. These vessels are superior to earlier torpedo boats, and being 165½ feet long (about 9 beams), are good sea boats.

The newspapers tell us that a destroyer of 33 knots is again contemplated, and it will be apparent that very high power will be required. The following table will show that in the 20-knot boats of the eighties it required 10½ horse-power per ton of displacement, and so on through each batch of vessels as they became larger.

In conclusion, I may be permitted, perhaps, to express a few opinions as to the utility of these vessels. As I have said, they appeal to marine engineers, because the Whitehead is a marine engineer's invention and is a weapon which all marine engineers can well manipulate; and I think that if a Coast Volunteer Corps could be established, composed largely of young marine engineers, for service in these vessels as coast

TABLE 1.

River Class Destroyers.	By Whom Built.	Speed Obtained on Full Speed Trials, Knots.	Coal per I. H. P. on the High Speed Consumption Trial, Pounds per Hour.	Air Pressure on Full Speed Trial, Inches.
Welland	Yarrow & Co.	26.2	1.65	1 8
Usk	"	26 1	1.77	1 6
Teviot	"	25.9	2.07	2 0
Ribble	"	25.8	1.57	1.6
Exe	Palm r's Co.	25.6	2.11	2 4
Waveny	Hawthorne Leslie	25.6	2.19	3.2
Derwent	"	25.7	2.24	2.8
Erne	Palmer's Co	25.6	2.25	2.5
Dee	"	25.5	2.28	2.6
Ettrick	"	25.6	2.33	2.6
Cherwell	"	25.6	2.34	2.7
Kennet	Thornycroft & Co	26.0	2.39	3.8
Jed	"	25.7	2.46	4.0
Itchen	Laird B os.	25 6	2.46	4.3
Blackwater	"	25.7	2.62	5.3
Arun	"	25.7	2.68	4.4
Foyle	"	25.6	2.79	4 4
Eden (turbine)	Hawthorne Leslie	26.2	tons cwt. 7 9 per hour.	3.3

TABLE 2.

Vessel.	Length, Feet.	Speed, Knots.	I. H. P. per Ton of Displacement.	Propellers.
Miranda	45⅛	16	14.7	Forged steel.
Torpedo boat	118	20	10.6	"
"	125	21	10.6	"
"	130	22	12.9	"
"	140	23	15.6	"
"	140	23	13 0	Manganese Bronze.
"	165½	25	15 0	"
River Class	220	25½	12 6	"
Destroyer	185	27	15.7	"
"	215	30	20.0	"
"	228	31½	21.1	"

defenders, not only the manipulation of the machinery and of the Whitehead, but also the firing of the guns, could be intrusted to such volunteers, and the pure navigation of the ships and boat-work done by men of whom there are so many around our coasts as trawlers, fishermen, and others. I suggest that the whole of our coasts could be defended by torpedo boats and destroyers, leaving the battleships to do their work on the high seas.

It has been said that the war in the Far East has proved the utility of the battleship, and that only. But it must be remembered that Admiral Togo had to nurse his destroyers and do the greatest injury with the smallest risk, so that had he had more destroyers, and so been enabled to risk more, we might have heard a different account of the deadly weapon, the Whitehead.

At all events, I think that, say, 1,200 men would be better utilized in craft of the destroyer and torpedo-boat description than putting the same number in a large battleship, which might be sunk by even one of these craft; and we have very high authority stating that four such craft, costing a fourth the price, and manned by a fourth of the crew of a battleship, would doubtless sink that battleship. And surely they would prevent her approach to our shores near enough for her guns to range us. Moreover, torpedo boats and destroyers remain war-worthy longer than battleships.

In these days, when conscription is being preached, it is well to consider alternatives. The thickly-inhabited islands of Great Britain have 3,740 miles of coast line. Allowing one destroyer or sea-going torpedo boat to each ten miles, we find that 200 destroyers and 174 torpedo boats, manned by twenty-one thousand sea-stomached young mechanical engineers and small-craft men, would give national mental repose at a cost of twenty millions sterling as a preliminary outlay and about two millions a year for wages and maintenance.

A CAVITY DUE TO STRAIN IN HEATING.

A BRIEF illustration will perhaps emphasize the importance to the testing engineer of familiarity with the minute details of industrial processes: A couple of years ago, while the finishing cut was being taken on a steel driving axle in a lathe, the operator noticed in the freshly cut surface what appeared to be a small flaw. On testing this with a pin the pin disappeared and quite a length of fine wire followed it. On taking out a transverse slice of the axle at this point a cavity was found in the metal which would hold ½ pint or more. The walls of the cavity were perfectly clean and bright, and but for the fact that the finishing cut just happened to open up the cavity a trifle its presence would not have been suspected and the axle would have gone into service. It is perhaps safe to say that one-quarter, or, possibly, one-third, of the cross sectional area of the axle was embraced in the cavity. We have seen a number of such cases and unfortunately the phenomenon is not too rare. Almost any practical steel maker when asked for the cause of such a cavity in what is apparently a solid piece metal would probably laconically answer, "Careless heater." In order to understand this statement it is necessary to say that many driving axles, even when they are finished, are about 11 inches in diameter, and that the bloom from which they are forged is considerably larger. If, now, such a bloom when cold is put into a hot furnace, the outside layers get hot long before the inside has begun to rise much in temperature. A severe strain due to the greater expansion of the outside layers is accordingly set up, which strain is enough occasionally to actually rupture the inside. Subsequent forging opens out this rupture into a cavity. The rupture is usually accompanied by a noise like a pistol shot. The unfortunate

part of the business is that there being a number of blooms in the furnace at one time it is impossible to tell which one has yielded to the strain. As would be expected, the larger the axle the more common this defect, and we know of one large railroad that bores a 2-inch hole through every axle over 8 inches in diameter that is destined for passenger service. The boring of the hole enables the cavity to be discovered either by the behavior of the drill or by sight examinations after the hole is finished. It is interesting to know that something over 2 per cent. of all axles bored are defective in this way.—From a paper by Charles R. Dudley.

[Continued from Supplement No. 1577, page 25274.]

THE PRESSURE OF EXPLOSIVES. EXPERIMENTS ON SOLID AND GASEOUS EXPLOSIVES.*

By J. E. Petavel.

PART II.—EXPERIMENTAL INVESTIGATION OF THE EXPLOSIVE PROPERTIES OF CORDITE.[1]

The maximum pressure developed by explosives can be measured with considerable accuracy by means of the crusher gage, which was devised some thirty-five years ago by Sir Andrew Noble.[2] The classical work since carried out by this investigator is too well known to need a mention here. Attention may, however, be drawn to one of the more recent papers, in which Noble publishes the cooling curves of cordite and describes the instrument by which they were obtained.[3] The apparatus is in principle not unlike an ordinary steam engine indicator, but the spring is initially compressed by an amount corresponding to nearly the full pressure of the explosion, and is automatically released when this pressure has been reached. By this ingenious contrivance the violent oscillations of the spring, which would be set up by the explosion itself, are avoided, and a clear record of the rate of fall of pressure is inscribed.

In ballistic tests the total energy imparted to the

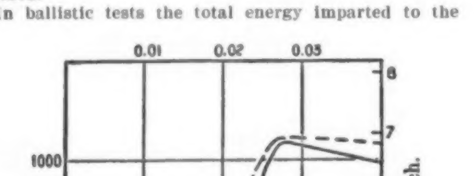


Fig. 9.—COMPARISON OF THE EFFECT OF IGNITION BY OXYHYDROGEN AND GUNPOWDER.

Cordite of 0.175 inch diameter in a cylindrical inclosure; charge uniformly distributed; gravimetric density 0.1; *A*, fired with oxyhydrogen gas; *B*, fired with fine-grained powder.

projectile is calculated from the readings of the Holden-Boulanger chronograph, and, in the case of specially constructed experimental guns, the Noble chronograph gives valuable information on the distribution of pressure within the gun itself.[4]

With regard to the more destructive explosives, such as blasting powders, dynamite, etc., their power is usually estimated by means of the Trauzl[5] lead block. At Woolwich this method has, however, been recently abandoned, an apparatus of the pendulum type being now in use.[6]

By the above methods the maximum pressure and the rate of fall of the pressure, or at least the total energy, can in most cases be satisfactorily estimated.

Comparatively little information is, however, available with regard to the initial part of the explosion; i. e., the behavior of the explosive from the moment at which it is fired up to the time when it is fully consumed.

This point deserves further investigation, the action of the explosive during this period being no less important than the question of the maximum pressure attained.

It must be borne in mind that any structure, whatever its nature, will behave very differently according

*Philosophical Transactions of the Royal Society of London.

[1] The explosive used in the course of this work was issued, by order of the Secretary of State for War, as representing the service cordite of the year 1902. Samples of three different sizes were included in the issue, the nominal sizes being 50/17, 20/17 and 3¾.

[2] Proc. Roy. Inst., vol. vi., p. 282, 1871; see also Phil. Trans. Roy. Soc., vol. 165, p. 49, 1875, and Phil. Trans., vol. 171, p. 203, 1880, etc.

[3] Proc. Roy. Inst., vol. 16, p. 329, 1900.

[4] Report Brit. Assoc., Oxford, 1894, pp. 523-540.

[5] Ber. Int. Kong. Angew. Chem., Berlin, 1903, vol. ii, pp. 299-303 and 462-465.

[6] Capt. Desborough's report. See 26th Report of H.M. Inspector of Explosives.

as it is exposed to a stress gradually applied, or is subjected suddenly to the same stress, or finally is submitted to violent oscillations of load.

In the case of a gun any abnormally rapid explosion gives rise also to another source of danger. The time elapsing between the ignition and the complete combustion of the charge may be insufficient to allow the inertia of the shot to be overcome and to move it through an appreciable distance. Should this occur, the products of combustion would be confined in an

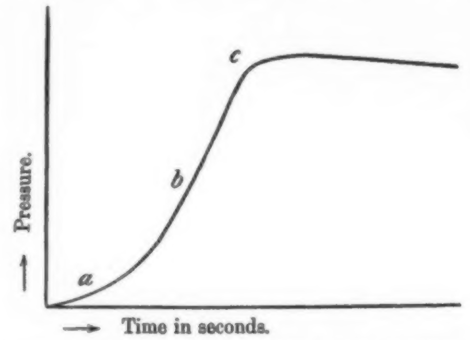


Fig. 10.—TYPICAL TIME PRESSURE CURVE RESULTING FROM THE EXPLOSION OF CORDITE IN CLOSED VESSEL.

unduly small space, and the pressure would rise above the safe limit.

The study of the initial stage of the explosion for various powders has formed part of the researches carried out by the Service des Poudres et Salpêtres in Paris. The gage first used by Vieille was a modification of the crusher gage,[7] while of late years he has worked with a new type of spring manometer.[8]

In Germany, Bichel, Brunswig[9] and others have suggested that the properties of explosives should be determined by measurements made at relatively low pressures, the results being deduced by extrapolation. Careful work has been carried out by Blochmann[10] under these conditions. The gravimetric densities[11] used

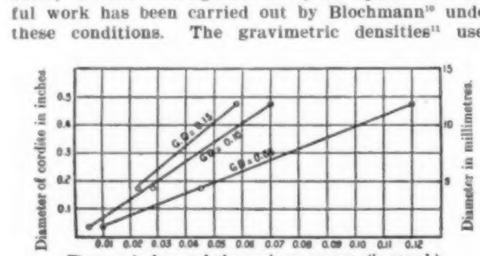


Fig. 13.—EFFECT OF THE GRAVIMETRIC DENSITY AND OF THE DIAMETER OF THE EXPLOSIVE ON THE TIME REQUIRED TO REACH THE MAXIMUM PRESSURE.

are from 0.01 to 0.02, and the maximum pressures recorded below one-half ton per square inch. It is necessary to point out that such a method may not infrequently lead to most serious errors.

Finally, it is generally understood that, in connection with this subject, numerous experiments have been carried out at Woolwich under the direction of Major Holden, but no results have as yet been published.

Experimental Work.

A preliminary question to be decided, before starting the series of experiments, referred to the method of ignition. The usual practice is to fire the charge of

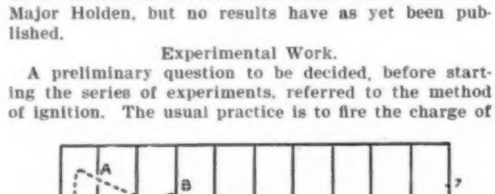


Fig. 11.—SHOWING VARIATION OF RATE OF EXPLOSION WITH SIZE OF CORDITE USED.

Gravimetric density 0.1; charge uniformly distributed; cylindrical inclosure used; *A*, diameter of cord 0.035 inch; *B*, diameter of cord 0.175 inch; *C*, diameter of cord 0.475 inch.

cordite by means of a small quantity of fine powder, which is ignited either by a percussion cap, or by a

[7] Comptes Rendus, vol. 112, p. 1052, 1891.

[8] Mémorial des Poudres et Salpêtres, vol. xi, pp. 157-210, 1902; see also Comptes Rendus, vol. 115, p. 1268, 1892.

[9] Ber. Int. Kong. Angew. Chemie, vol. ii, pp. 282-299, 1903.

[10] Dingler's Poly. Journ., vol. 318, pp. 216 and 332, 1903.

[11] Gravimetric density is defined as the ratio of the weight of the charge to the weight of that volume of water which would fill the inclosure; it is, therefore, numerically equal to the specific gravity of the gas produced when the explosive is fired.

metallic wire which is brought to incandescence by an electric current. Some records were taken in this way, but it was soon found that alterations in the amount and disposition of this firing charge, though leaving the actual maximum pressure almost unaffected, caused some variation in the shape of the pressure curve (see Fig. 9). When a relatively small quantity of the igniting charge is used in an inclosure of considerable length, only the part of the cordite in immediate proximity seems at first to take fire, and the flame is then propagated from layer to layer of the explosive. When the firing charge is larger, or the dimensions of the inclosure smaller, or, thirdly, when very fine cord is used, a more satisfactory ignition is obtained. This point in itself would be well worth more careful investigation, but as the present research refers principally to the properties inherent in cordite itself, it was desirable to be independent of such disturbing factors. The ideal conditions would be realized if a method could be found of igniting every particle of the explosive at the same instant over its entire surface. These conditions are approached by the process used.

After the required quantity of cordite had been filled in and the explosion chamber closed, the air therein contained was displaced by a mixture of oxygen and hydrogen at, or near, atmospheric pressure, and this was fired off in the usual way by an electric current. The velocity of the explosion of this mixture is such that the effect of the gaseous combustion is practically over before the pressure of the burning cordite begins to make itself felt, and each cord, being entirely surrounded by the flaming gases, cannot fail to ignite over its entire surface. On the records the impact of this preliminary explosion is marked by a slight tremor occurring just before the actual rise of pressure occurs. The pressure due to the gaseous explosion is about 10 atmospheres which, when compared with the 1,000 or

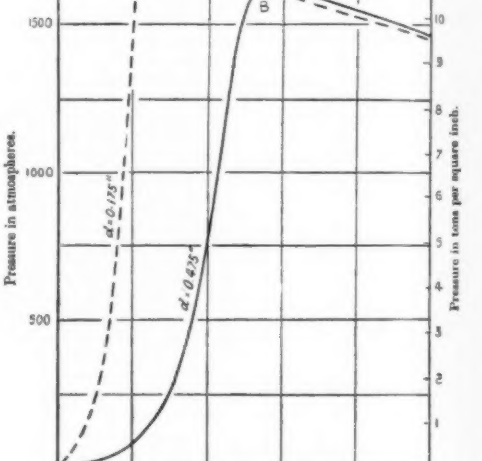


Fig. 12.—SHOWING VARIATION OF RATE OF EXPLOSION WITH SIZE OF CORDITE.

Gravimetric density 0.15; charge uniformly distributed; cylindrical inclosure used; *A*, diameter of cord 0.175; *B*, diameter of cord 0.475.

2,000 atmospheres resulting from the explosion of the cordite, does not form a serious correction.

General Shape of the Curves.

All the records exhibit certain general characteristics. The typical curve of rise of pressure is illustrated in Fig. 10. It consists of three parts: (*a*) beginning nearly asymptotical to the time axis and, gradually rising more rapidly, corresponds to the first stage of the combustion; (*b*) referring to the full blast of the explosion, shows a much faster and almost constant rate of rise; while at (*c*) the rapid decrease in the surface of the explosive can no longer be counterbalanced by the accelerating effect of the higher pressure. At *c*, therefore, the curve turns round sharply and merges into the cooling curve. So much for the general shape of the records. As we shall see below, a more detailed study shows that, while conserving the same configuration, the actual curve may, according to circumstances, either be smooth or made up of continuous vibrations, or, thirdly, composed of a series of small but sharp steps corresponding with the successive impacts of the explosion wave.

Effect of the Diameter of Cordite.

The velocity of the explosion depends primordially on the diameter of the cordite, but is modified to some extent by the distribution, the method of firing, and more especially by the gravimetric density. Fig. 11 shows the rise of pressure for three different diameters of cord (0.475 inch, 0.175 inch, 0.035 inch); the gravimetric density is in every case 0.10. The largest size is used for heavy ordnance, the smallest size for the army rifle. The three tests were made under the same conditions and in the same inclosure.

Fig. 12 relates to a similar experiment carried out at a higher pressure. Lastly, in Fig. 13, the time required for the complete combustion of cordite of various diameters is plotted for three distinct gravimetric densities.

The relation between the time occupied by the explosion and the diameter of the cordite, as shown in this

figure, is practically a linear one, the lines converging toward the zero of time and diameter. We may, therefore, conclude that the combustion of finely divided cordite is nearly instantaneous. Under such conditions the result of an explosion would be very destructive, and it is possible that some abnormal effects which have on certain occasions been observed may be due to the pulverization of the explosive at any early stage of the combustion.

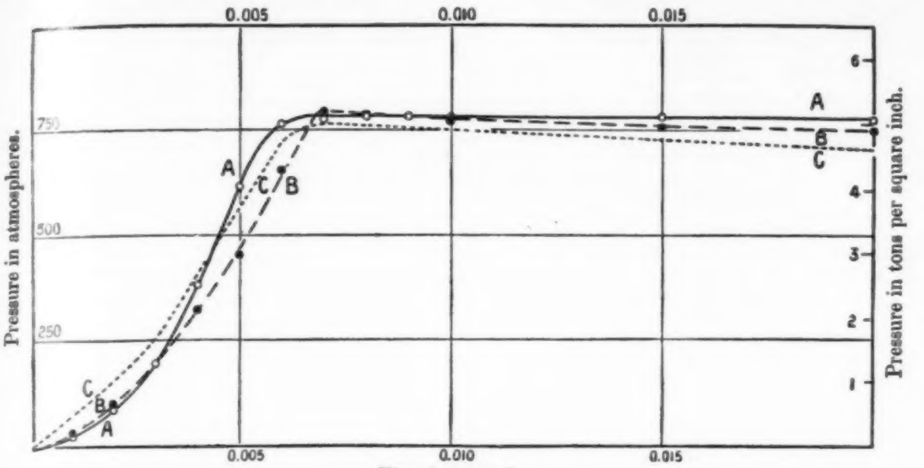


FIG. 14.—SHOWING THE RATE OF RISE OF PRESSURE FOR CORDITE OF THE SMALLEST DIAMETER. DIAMETER 0.035 INCH (0.89 MILLIM.).

A, spherical inclosure; charge uniformly distributed; gravimetric density 0.074. *B*, cylindrical inclosure; charge uniformly distributed, gravimetric density 0.075; *C*, cylindrical inclosure; charge concentrated in one-quarter of cylinder, nearest the recorder; gravimetric density 0.075.

However rapid an explosion may be, it remains, in principle, very distinct from a detonation. In an explosion the combustion is propagated from layer to layer without discontinuity. In a detonation the chemical reaction is practically instantaneous and simultaneous throughout the entire mass. The determining cause is, in this case, a compression wave of sufficient intensity to raise the material to its temperature of ignition.

Let us take for the sake of illustration a numerical example, although the values employed can only be rough estimations, and suppose a sphere of cordite 1 centimeter in diameter under a gravimetric density of 0.1. If this were ignited in the ordinary way, the combustion would travel toward the center of the sphere at an average rate of 8 centimeters per second and the maximum pressure would therefore be reached in 0.063 second. If, on the other hand, the material were to detonate, the detonation wave would travel through the mass at a speed of something like 800,000 centimeters per second,[12] and the total time occupied would be one hundred thousand times less.

In an explosion we have usually to deal with pressures which may be considered as statical as far as their action is concerned; in a detonation with a dynamical pressure or impact. The impact of the products of combustion traveling with enormous velocity may correspond in effect to an instantaneous pressure five or ten times greater than the normal pressure calculated from the composition of the explosive and its heat of reaction.

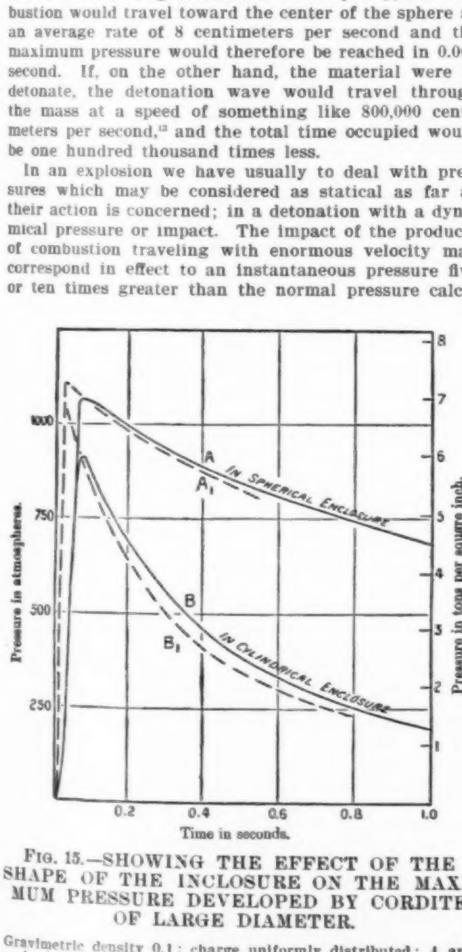


FIG. 15.—SHOWING THE EFFECT OF THE SHAPE OF THE INCLOSURE ON THE MAXIMUM PRESSURE DEVELOPED BY CORDITE OF LARGE DIAMETER.

Gravimetric density 0.1; charge uniformly distributed; *A* and A_1, in spherical inclosure; *B* and B_1, in cylindrical inclosure; *A* and *B*, diameter of cord 0.475 inch (12.07 millimeters); A_1 and B_1, diameter of cord 0.175 inch (4.44 millimeters).

A typical case of this kind occurred when working with a compressed mixture of coal gas and oxygen. The total pressure of the explosion should have been some 4 or 5 tons per square inch. The mixture, however, detonated, and the solid steel piston of the recorder, though incased in a steel cylinder over 2 inches thick, was expanded outward like the head of a rivet.[13] It is not easy to estimate exactly the statical pressure required to produce a corresponding effect, but it cannot be less than 25 tons per square inch.

To return now to work on cordite, the results obtained with one of the smallest diameters in use are shown in Fig. 14. It will be seen that, though the time occupied by the combustion is small, amounting to less than 0.008 of a second, the shape of the curve is perfectly normal, showing clearly the three distinct stages of combustion already referred to.

The law of combustion by parallel surfaces as expounded by Vieille[14] applies well to the case of cordite.[15]

The speed at which the flame travels inward toward the center of each cord is uniform and relatively slow. When unconfined, cordite burns at a rate of about 0.5 centimeter per second. In a closed vessel the average speed increases to 5 centimeters per second for an explosion developing 500 atmospheres, 8 centimeters for a maximum of 1,000 atmospheres, and 11 centimeters per second for 2,000 atmospheres.[16]

The shape of the curve representing the rise of pressure depends essentially on two factors: (1) on the surface of the explosive exposed to combustion, and hence on the radius of the cords at each instant during the reaction; (2) on the radial speed at which the zone of combustion is traveling toward the center of each cord. This speed may be taken as proportional to the pressure. The formula $S = ap$ (where S is the speed in centimeters per second, p the instantaneous pressure in tons per square inch, and a an empirical constant equal to about 3.5) may be of use where it is not possible to make a direct experimental determination.

The maximum pressure (P) developed by a given charge is usually well known, and by aid of the above formula the curve of rise of pressure can therefore be obtained. The radius of the cordite for successive intervals of pressure ($p = 0.1\,P$, $p = 0.2\,P$, etc.) is first computed, and the time required to burn through the corresponding distance at the average pressure ($p = 0.5\,P$, $p = 0.15\,P$, etc.) is then determined. In calculating the radius, the volume of the unburnt explosive must, of course, be taken into account, and this renders the work somewhat tedious.

The formula does not take into account the fact that under experimental conditions some time elapses while the flame is spreading before the normal rate of combustion is set up. The zero of the calculated curve is, therefore, shifted somewhat to the right, and a sharper slope given to the initial stage (*a*, Fig. 10).

It may with some truth be argued that the error occurring at a very low pressure would not affect the results as applied to ballistics, the calculation and experimental curves being in agreement by the time the motion of the shot commences. It is hoped, however, that the day is not far distant when we shall be able to obtain an indicator card from a gun with the same ease as we now indicate other heat engines; approximate calculations such as the above will then cease to be of practical value.

We have explained above the system used for firing the charge. When the key is pressed, the atmosphere of oxyhydrogen, with which the inclosure has been filled, explodes, and the cordite is surrounded by a sheet of flame. The time at which this takes place is recorded by a slight tremor of the gage. The charge does not ignite at once,[17] for though the explosive is surrounded by an intensely hot flame, a quite appreciable time is required for its surface to rise to the temperature of ignition.[18]

The ignition begins at the ends of each stick or at other parts, where, for instance owing to a blister, the conductivity has been reduced. The last parts to be attacked are those which were in contact with the walls of the inclosure or with some other portion of the charge. These circumstances, together with a slow rate of combustion which is characteristic of cordite under very low pressures, account for the gentle slope of the first part of each curve.

When fully ignited, each particle is freely suspended in space, being kept from direct contact with other bodies by the rush of flame issuing from its surface. It is to these conditions that the law of combustion by parallel layers accurately applies.

While the combustion is taking place, heat is being continually transmitted to the walls of the inclosure, and the maximum pressure attained will therefore be less for a slow explosion than for a fast one; the actual effect may be seen by reference to Figs. 11, 12 and 15.

The heat loss accounts also, as stated above, for the manner in which the curves of rise and fall of pressure merge together. By the time the maximum pressure is nearly reached the diameter of each particle of explosive is greatly reduced. The weight of substance consumed per unit time begins therefore to decrease, although the flame is actually advancing toward the axis of each cord at an ever increasing speed. Finally, the combustion just counterbalances the total thermal loss, and the curve of pressure remains for an instant practically constant at its maximum value.

EXPERIMENTS ON SOLID AND GASEOUS EXPLOSIVES.

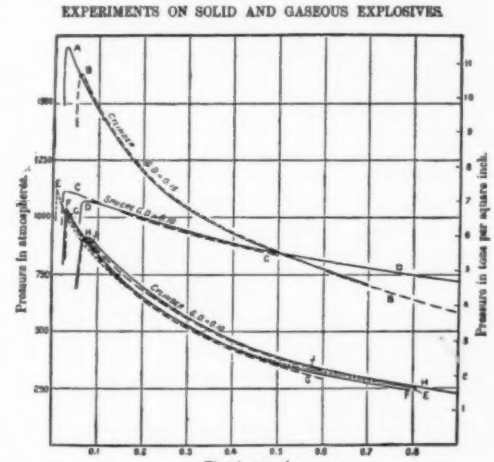


FIG. 16.—EFFECT OF THE DIMENSIONS OF THE INCLOSURE ON THE RATE OF COOLING OF THE PRODUCTS OF COMBUSTION.

A, cylindrical explosion vessel; gravimetric density 0.15; diameter 0.175; uniformly distributed.
B, cylindrical explosion vessel; gravimetric density 0.15; diameter 0.475; uniformly distributed.
C, spherical explosion vessel; gravimetric density 0.1; diameter 0.175; uniformly distributed.
D, spherical explosion vessel; gravimetric density 0.1; diameter 0.475; uniformly distributed.
E, cylindrical explosion vessel; gravimetric density 0.1; diameter 0.035; uniformly distributed.
F, cylindrical explosion vessel; gravimetric density 0.1; diameter 0.175; uniformly distributed.
G, cylindrical explosion vessel; gravimetric density 0.1; diameter 0.175; not uniformly distributed.
H, cylindrical explosion vessel; gravimetric density 0.1; diameter 0.475; uniformly distributed.
J, cylindrical explosion vessel; gravimetric density 0.1; diameter 0.475; not uniformly distributed.

Effect of the Inclosure.

We have just referred to the thermal loss due to the cold walls of the explosion chamber. The total loss, *cæteris paribus*, is proportional to the time.

When the diameter of the cordite, and consequently the time occupied by the combustion, is very small, the theoretical value of the maximum pressure is closely approached, and the shape and size of the inclosure have but little effect (compare *A* and *B*, Fig. 14). These factors become, however, of considerable importance in determining the maximum pressure developed by the slower burning cordite (see Fig. 15).

The shape of the cooling curve depends, on the other hand, essentially on the dimensions of the inclosure. In Fig. 16 the facts are clearly illustrated by the results of comparative experiments carried out respectively in a sphere and in the cylinder.

It is proposed to reserve the general discussion of the questions of dissociation and rate of cooling for the third part of the present research; we shall then be dealing with gaseous mixtures of simple composition which will serve as a natural introduction to the consideration of more complicated questions. A few words are, however, necessary with regard to the somewhat unusual conditions under which the cooling of

[12] Able found that the rate of detonation of a train of dynamite or guncotton was about 608,000 centims. per second. See also Sébert, Berthelot and Mettegang. The latter (Ber. 5. Int. Kong. Ang. Chem., Berlin, 1903, vol. ii., p. 322) gives 700,000 centims. per second as the detonation rate of dynamite.

[13] A similar effect is recorded by Noble (Proc. R. I., 1900) as having been produced on the copper of a crusher gage by a charge of lyddite.

[14] Comptes Rendus, vol. 118, pp. 346, 458, 912; 1894.

[15] The peculiarly regular combustion of cordite was first noticed by Noble, who in 1892 (Proc. Roy. Soc., vol. 52, p. 129) remarks that the pieces of cordite blown from the muzzle of the experimental gun he was using were so uniformly decreased in diameter that they might readily have been mistaken for newly manufactured cordite or of smaller diameter.

[16] The time required for the full pressure to develop is, therefore, proportional to the diameter of the cord. The formula $L = r/c$ (where L is the time in seconds and r the radius in centimeters) gives a fair approximation, though, as we shall see, the actual time varies somewhat, according to the conditions of the experiment. The constant c is characteristic of the explosive and, of course, equal to the above rates of combustion.

[17] In the appended tables and curves, time is counted from the instant the cordite ignites, as marked by the first permanent rise of pressure.

[18] A stick of cordite may under ordinary conditions be passed comparatively slowly through the flame of a Bunsen burner without igniting. If, however, its surface has previously been scratched or scored, the smaller particles will ignite at once and set fire to the mass.

the products of combustion of a solid explosive takes place.

Under ordinary circumstances the convection and conductivity of the gas itself are the ruling factors which determine the rate of cooling.

The thermal capacity of the gaseous mixture and the rate at which heat can be transmitted through it are low compared with the corresponding properties of the inclosure. These facts hold true whether the latter is water-cooled or not.

In such cases neither the inner surface of the inclosure nor the layer of gas in contact with it rise much above atmospheric temperature, and the rate at which heat is dissipated depends on the temperature gradient which is set up in the gaseous mass.

In previous papers[19] I have pointed out how the rate of transmission of heat in a gas varies with the pressure. In the case of air, for instance, the law

$$E \times 10^{6} = 403p^{0.56} + 1.63p^{0.91}\,\vartheta$$

was verified up to 1,000 deg. C. and 170 atmospheres.[20] At this pressure already air transmits heat at the same rate as a substance having twenty times the conductivity of air at atmospheric pressure.

When considering the products of an explosion, it must be remembered that the effective conductivity of the gas is further increased by its state of rapid motion. It is also augmented by the large proportion of hydrogen and water vapor contained therein.

As a result the temperature of the walls of the inclosure rises rapidly as the cooling of the gas proceeds, and before long the rate of cooling will depend essentially on the conductivity of the walls of the inclosure and not on the properties of the gas. The heat abstracted per unit time will then be simply proportional to the temperature.

If the logarithmic decrement of the latter part of the curve is measured, it will be found that the theory is confirmed in this respect by the results of the experiments.

The quantity of heat which is transmitted to the walls of the inclosure during the brief period occupied by the cooling of the gas is much greater than would occur in cases met with in ordinary engineering practice. With a gravimetric density of 0.1 the amount of heat to be absorbed per unit surface of our cylindrical inclosure is some hundred times as large as that which would be absorbed by the cylinder of an ordinary gas engine.

In the case of artillery of large caliber the inner surface of the steel probably attains a temperature close to its melting-point and the correspondingly plastic material yields easily under the combined friction and chemical action of any escaping gas. In the case of small arms, the temperature being limited by the relatively small volume and therefore small thermal capacity of the gaseous mass, practically no erosion takes place.

To return now to the experimental work. In the following table the time required for the pressure to fall to three quarters, one half, one quarter of its maximum value is given for a number of distinct experiments, whereas the cooling curves for three different diameters of cordite at gravimetric densities of 0.1 and 0.15 will be found plotted in Fig. 16. It is noticeable that after the first tenth of a second the curves taken under similar conditions, but for various sizes of explosive, lie closely together, showing that the diameter has no material effect on the subsequent rate of cooling.

When we refer, however, to the table, we see that the times required to reach a given fraction of the maximum are different for different diameters.

This apparent discrepancy is explained by the fact that the total quantity of heat absorbed is primordially a function of time. When the combustion is very rapid, the maximum pressure is reached while the walls of the inclosure are still cold and the percentage fall of pressure per unit time is high. With a slow-burning cordite the surface of the inclosure becomes considerably heated during the combustion of the explosive, and after the maximum the percentage fall of pressure is correspondingly lower. Briefly stated, at any fixed interval of time after ignition the total heat absorbed by the inclosure, and, therefore, the temperature of its inner surface, will be nearly the same for all diameters of the explosive. In consequence, the rate of cooling as measured by the rate of change of pressure at any stated time is unaffected by the speed of combustion.

The rate of cooling for a given volume of the inclosure does not vary, as is usually assumed, in proportion to the surface, but nearly as the square of the surface.

It will be noticed that the cooling in the cylinder is about four times as rapid as in the sphere, whereas the ratio of the two surfaces is as 2.17 to 1.

In such massive inclosures the heat generated by the explosion is at first entirely absorbed by the inner layers of the steel walls. It does not travel to the outside until some time after the explosion is over. A decrease in the surface has, therefore, a double effect. The heat to be absorbed per unit area and the average thickness of metal through which this heat must be transmitted are both increased.

(To be continued.)

RATE of Cooling of Products of Combustion.

Enclosure	Spherical.			Cylindrical.											
Diameter of cordite / Gravimetric density	0·175" 0·05	0·475" 0·10	0·175" 0·10	0·475" 0·10	0·175" 0·10	0·175" 0·10	0·035" 0·10	0·475" 0·15	0·175" 0·15	0·035" 0·075	0·035" 0·075	0·475" 0·10	0·175" 0·10	0·175" 0·10
Distribution	Uniform.			Uniform.		Uniform (gunpowder ignition).		Uniform.			Non-uniform.			
Time, in seconds, required for the pressure to fall to three quarters of the maximum value	0·52	0·54	0·45	0·13	0·09	0·13	0·08	0·13	0·13	0·07	0·05	0·12	0·10	0·10
Time, in seconds, required for the pressure to fall to one half of the maximum value	—	—	—	0·34	0·27	0·35	0·26	0·48	0·44	0·18	0·17	0·33	0·29	0·28
Time, in seconds, required for the pressure to fall to one quarter of the maximum value	—	—	—	0·80	0·69	0·72	0·69	—	—	0·45	0·45	—	0·77	—

[19] Phil. Trans., A. vol. 191, pp. 501, 524, 1898; and vol. 197, pp. 229-254, 1901.

[20] E is the heat abstracted from each square centimeter of surface of the hot body measured in therms per second per degree temperature interval. ϑ is the temperature of the hot surface measured in degrees Centigrade, and p the pressure of the surrounding gas in atmospheres.

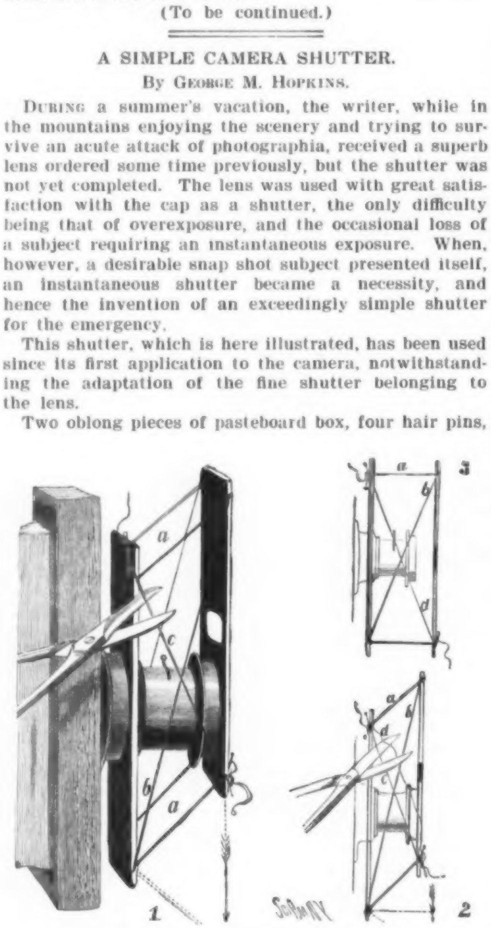
A SIMPLE CAMERA SHUTTER.

By GEORGE M. HOPKINS.

DURING a summer's vacation, the writer, while in the mountains enjoying the scenery and trying to survive an acute attack of photographia, received a superb lens ordered some time previously, but the shutter was not yet completed. The lens was used with great satisfaction with the cap as a shutter, the only difficulty being that of overexposure, and the occasional loss of a subject requiring an instantaneous exposure. When, however, a desirable snap shot subject presented itself, an instantaneous shutter became a necessity, and hence the invention of an exceedingly simple shutter for the emergency.

This shutter, which is here illustrated, has been used since its first application to the camera, notwithstanding the adaptation of the fine shutter belonging to the lens.

Two oblong pieces of pasteboard box, four hair pins,



A SIMPLE CAMERA SHUTTER.

four common pins, a long thin rubber band, a piece of black velvet, and a piece of thread constitute the materials, and the time required for making the apparatus was twenty minutes.

In the center of one of the pieces of pasteboard was formed an aperture to fit over the threaded end of the lens tube, and in the center of the other oblong piece of pasteboard was formed a wide transverse slit, and a piece of black velvet was attached to one side of the pasteboard and carried over the edges around the slit. In the absence of other forms of wire four hair pins, *a*, were straightened, the ends of each one bent at right angles in the same direction and inserted in opposite edges of the pasteboard above and below the lens tube. Two of the common pins were inserted in the front of the lower part of the movable portion of the shutter, from opposite directions, forming a cleat for the reception of the piece of thread, and in a similar way two pins were inserted in the stationary pasteboard. A slender rubber band, *b*, was stretched around diagonally opposite ends of the pieces of pasteboard within the wire arms, *a*, and was prevented from slipping by the ends of the arms which entered the pasteboard.

This shutter was set by raising the front part so as to bring the lower imperforate portion against the front of the lens tube, thereby shutting off the light, then bringing the thread, *c*, already attached to the cleat on the stationary part, around the cleat on the movable part. The exposure was made by cutting the thread by means of a pair of scissors as shown in Fig. 1. The focusing was done while the shutter was held open by another thread, *d*, having a loop in it, which was slipped on the front cleat as shown in Fig. 3.

To make a slightly prolonged exposure the thread, *c*, which held the shutter closed, was cut first as shown in Fig. 2. The looped thread, *d*, which held the shutter open was cut immediately after it, the time elapsing between cutting the first and second threads being the time of exposure. The rapidity of the shutter is increased by adding another rubber band.

WEALTH OF OUR FARMS.

IN view of the vast increase that has taken place during the past decade in the number and wealth of our industrial establishments and in the value of our manufactured products, it will be surprising to many people to learn that our farms still greatly exceed in value and as a source of revenue every other source of wealth, not even excluding our great manufacturing enterprises. The wealth production of the farms of the United States reached in 1905 the highest amount ever attained in this or any other country, the total figure being nearly six and one-half billion dollars. Four of the crops reached new records as to value, namely, corn, hay, wheat, and rice. Corn exceeds previous yields both in amount and in price, and hay, wheat, and rice reached new figures as to value only. The general average of production was high in the case of every crop, and the prices ran higher still. The Secretary of Agriculture estimates that in addition to the enormous yield of wealth, the farms of the country have themselves increased in value during the past five years by over six billions of dollars; and he puts the matter dramatically when he states that with every going down of the sun during the past five years, there has been registered an increase of three million four hundred thousand dollars in the value of the farms of the country. An analysis of the principal crops for the year shows that corn reached its highest production with 2,708,000,000 bushels, a clear gain of 42,000,000 bushels over the very profitable year of 1899. The hay crop is valued at 605 million dollars; cotton at 575 millions; wheat at 525 millions; oats, 282 millions; potatoes, 138 millions; barley, 58 millions, and tobacco at 52 million dollars. Very remarkable is the increase of 54 million dollars in the value of dairy products, which reached the total valuation of 665 million dollars. The farmer's hen, says the Secretary, is becoming a worthy companion to the cow, the annual production of eggs being now 20 billions. Poultry products have climbed to a value of over half a billion dollars, so that poultry competes with wheat for precedence. The total value of horses is estimated at $1,200,000,000. There are over 17½ millions milch cows, valued at nearly half a billion dollars. During the year farm produce to the value of 827 million dollars was exported. During the last sixteen years the domestic exports of farm products have amounted to 12 billion dollars, or one billion dollars more than enough to buy all the railroads of the country at their commercial valuation. Clear evidence of the prosperity of the farmer is seen in the fact that under a recent amendment of the national banking law, allowing the establishment of banks with a capitalization of less than 50,000, there have been 1,754 such banks established in the last year, nearly every one of which, says the Secretary, is located in a rural community and the capital furnished by farmers. For the first time in the financial history of the South, the deposits in that region exceed one billion dollars. Should there be no relapse from his present position as a wealth producer, three years hence the farmer will find that the farming element, which forms thirty-five per cent of the population, has produced an amount of wealth within the preceding ten years equal to one-half of the entire national wealth produced in three centuries.

CAUSES OF FAILURE IN THE CONCRETE BLOCK BUSINESS.*

By O. U. MIRACLE.

IT certainly would be presumptive on my part to assume to tell you all the causes of failure or lack of success in the concrete-block industry. Many theories may be found inefficient when put to practical tests, so I shall only treat the subject in the light of my own observations in the field, and shall point out the most glaring dangers which seem to confront us, in order that we may overcome them.

In looking over the field I find that failures are due to a great variety of causes. Right here I want to again remind the manufacturers of concrete machinery of the grave responsibility of the position which they occupy in this matter. The field has proven such an interesting one that it has attracted investments by men in all walks of life. Many have engaged in this business whose fund of knowledge on the subject was of necessity limited. They have largely depended for their information upon the literature put out by the various machinery manufacturers. This information has in many cases, either through ignorance of the subject or a desire to make the proposition look more attractive than it really was, been

* Paper read before the Cement User's Association.

very misleading, and the instructions given, if followed, would in many cases result in dire disaster. I most earnestly urge that the machinery manufacturer, in preparing his literature, confine himself to facts. Even in the past few weeks I have seen literature in circulation, from what I considered reputable concerns, advertising certain cement-block and brick machines which gave the estimated cost of the manufactured product at less than the cement alone required to produce a good article would cost. A gentleman told me that he had about made up his mind to buy a certain type of machine because the manufacturer told him it pressed the blocks so hard that they could be laid in the wall the next day after making. These rash statements often come from the over-zealous salesman, but altogether too often from the machinery manufacturer himself.

In almost all estimates of cost of manufacture, I find that account has been taken only of the direct expense. No mention whatever is made of indirect expense, such as advertising, superintendence, interest on the investment, depreciation, loss from breakage, bad accounts, etc. There is sufficient profit in the business to place it on a much higher plane than has been aimed at by many manufacturers. The facts of the matter are, including all these extra items of expense, there is still more chance for gain in this business than in the manufacture or production of any other building material of equal strength and lasting qualities. Up to the present time we have been very lame in the lack of standard specifications for the manufacture of this product. In order to get this matter on a uniform basis it was brought up at the meeting of the cement-block manufacturers, held in Chicago last June, and, as chairman of the committee, I hope to submit a progress report at an early date.

Within the past week a case has been brought to my notice where the party failed absolutely. He did not attempt to secure any business on merit; he had the idea that he must always be below his competitors to get orders. Under these conditions, what could you expect but inferior material and poor workmanship and a dissatisfied customer, who uses his influence against cement work at every opportunity?

Then we have the man who goes into business with insufficient capital. Some manufacturer has sold him a machine or partial equipment simply because he had the price or a part of it; he gets credit of his local dealer to the extent of the price of a few barrels of cement at a good round price. He makes a few blocks and sells them while they are yet too green for use in order to get funds for his pressing needs. He discovers, on account of his men being new to the business or from some other reason, that the blocks cost him much more than he anticipated or twice as much as the over-anxious salesman told him they would. He is short on profits and has already established a selling price at too low a figure. The tendency then is to attempt to make a profit at the already established price of cutting down the amount of cement used and correspondingly increasing the amount of sand. The results are too well known. He is down and out in a short time, condemns the business in general and the machine in particular that he bought, and is not slow to discourage others. By the time the report of his failure gets into about the third or fourth hands the conditions responsible for the results are lost sight of, and the report is spread broadcast that the business is a fizzle.

Next we come to the architect. He occupies a very imporant relative position in this matter, and his adverse criticism has no doubt proven a stumbling block to many of you. The value of his opinion and indorsement has been too lightly estimated by many. His position has of necessity been one of great care and caution. He is not willing to depart from fields of well-known practice for the mere novelty of an experiment. His position must be secure, but he has been a very careful student of the concrete block, and where a year or two ago he turned a deaf ear to the proposition he has discovered now that the material is already established, and he is willing to consider it for his requirements. His first and most important objection is lack of quality. Assure him of this, and he is ready to make a beginning. But he is immediately confronted with the question of appearance and utility. His objection as to appearance is certainly justified by certain glaring examples. It is lamentable that a material so easily susceptible to artistic designs has been so shamefully treated. Each of you can bring to your mind a building of concrete blocks, every one of which is of exactly the same size and the same style of rock-face design, with no sign of an attempt of ornamentation. There is no legitimate excuse for this neglect, and do you think it is any wonder that Mr. Architect finds fault with the appearance of this kind of a building? He can get the same effect in appearance with the cheapest kind of boards covered with still cheaper stamped sheet iron. He wants more variety of design, and if you will set about it there is nothing easier than for you to give it to him. True, additional design means added expenses, but you will be placing the business on a higher plane and your profits will increase correspondingly.

I have visited many yards where the owners were making less than half the designs and sizes of block their outfit was capable of turning out. While it is true there has been a demand for this rock-face block which you all make, I hope the time will come when you will get away from this idea entirely. It is at best but an imitation. As I have said on other occasions, I believe that this material is entitled to a distinct classification of its own, and a building made of it should be designated as a concrete building, and not as artificial stone, as so many call it.

One of the handsomest buildings I have ever seen of concrete was made of all plain-face blocks for the body of the building, with bevel quoins at the corners and openings, with a few ornamental designs utilized as belt course and cornice.

Another just objection of the architect is the extreme porosity or permeability of many blocks. This, combined with the strength of the material, is the all-important part of this proposition, and these objections are being rapidly overcome. This comes properly under the subject of manufacture and specification, and I shall only touch lightly upon it, as so important a subject is worthy of more lengthy consideration. The results obtained in this direction depend upon the following five vital points:

First—Proper selection and proportioning of materials.

Second—Careful mixing and complete incorporation of the ingredients.

Third—Careful and thorough tamping.

Fourth—Care in curing.

Fifth—Care in laying.

Proper Selection and Proportioning of Materials.—The cement should in all cases be a first-class Portland. In the selection of sand and aggregates the greatest care should also be exercised. Sand should be practically free from clay, loam or other soluble matters, notwithstanding the fact that many tests have shown that a small proportion of clay is not harmful. I believe it to be a very dangerous practice to recommend the use of sand containing any perceptible amount of clay from the fact that the average worker has no facilities for determining the percentage found in his material. If possible, the sand should be graded in sizes so as to reduce the voids to the smallest possible amount. The percentage of cement used with the sand should be such as to perfectly fill these voids. For determining the voids the water test may be employed without laboratory facilities. Average sand is found to contain 25 to 35 per cent voids, indicating the necessity of using this percentage of cement to make a perfect sand-cement mortar. Where aggregates are employed the voids in the aggregate may be determined in the same manner as they are in the sand, and an amount of the sand and cement mixture equal to the amount of voids in the aggregate should be used to make a perfect stone.

Careful Mixing and Complete Incorporation of the Ingredients.—Machine mixing is at all times preferable and invariably produces a better concrete by at least 10 to 15 per cent than can be made by hand mixing. The materials should be thoroughly incorporated and mixed until of uniform color.

When an aggregate is used the sand and cement should be well mixed first; then the aggregates and water may be added at the same time.

I believe that with any of the machines now on the market a much wetter mixture can be used than is generally employed if proper care is taken of the face plates. The face plates should be kept clean with a wire brush and be given a coat of oil or shellac as frequently as once a day.

Careful and Thorough Tamping.—The tamping should commence with the placing of the first shovelful of material in the mold, and should continue until the mold box is full. A small face tamper should be used, and quick, sharp blows should be struck.

Many unsightly buildings have been put up of blocks which showed unevenness in their texture on account of careless and uneven tamping.

Care in Curing.—No part of the manufacture of concrete blocks is more important than the curing, and I regret to say that this essential part of the manufacture is altogether too frequently disregarded.

Blocks should be kept moist for at least seven days after making. The water should be applied with a spray or sprinkler immediately after the initial set has taken place, or as soon as it can be applied without washing the stone.

Another fault that I have discovered in this connection is the fact that many yards do not carry sufficient stocks of blocks on hand—they wait until they have secured the contract before making the stone, and they are in this case rushed into the building too green, and bad results will inevitably follow. No concrete stone made in the manner above described should be laid in the wall until it is at least thirty days of age. Green blocks should never be exposed to the rays of the sun or warm currents of air during the first seven days, when they are supposed to be kept moist. In the early stages of this business I have seen blocks made under an open shed, immediately placed out on a hillside, exposed to the sun and wind, with no water applied, except such as was pumped with a common wooden pump and carried in buckets, and you all know too well the results that come from this careless haphazard method.

Is it any wonder that blocks made in this manner are porous or that they absorb moisture readily?

Many of you have seen buildings of concrete blocks which showed bad cracks in the wall. A building of this material though built of any other substance, but in nine cases out of ten where I have found cracked buildings I have found this result came from laying the blocks in the wall too green. They must have at least thirty days in which to cure, and they are better if they are sixty days or even six months old.

Care in Laying.—Too great stress can not be put upon this important part of the business. A mortar of equal parts of lime and cement to two or three parts of sand should be used and all blocks carefully bedded and butted on the ends, and the joints well pointed up. This pointing should be done at the time of the laying, as, if done at some later period, the blocks are apt to absorb the moisture from the mortar, thereby loosening it so that it will drop out.

Some blocks are provided with small oval openings at the ends for the reception of a soft cement mortar. After a course of this style blocks has been laid in a wall the mason should go along the wall with a measure of mortar sufficiently plastic to pour into these oval openings. This not only insures a tight joint, but acts as a dowel to tie the wall. I have seen many jobs completed which were very unsightly on account of the carelessness of the mason in allowing the blocks to become spattered with the mortar. This can easily be avoided, and I have found it in most cases comes from masons who are prejudiced against the use of concrete blocks.

Summing up, we find that we have arrived at a very vital and important point in the progress and development of this business—we have arrived at the "parting of the ways."

There will be two distinct classes of this material —viz., good and bad, the latter coming from those lacking experience and knowledge of the business, and let us use our united efforts to set them right. If you have a new competitor in your town, go to him and tell him how to make good work, and it will invariably assist in bringing about a uniform and superior quality of concrete blocks. There will always be some failures, as there are failures in any business, but by united effort and care we can reduce these failures to a minimum.

THE BEGINNING OF A MINING CAMP.

AFTER the first discovery, and the usual staking out and recording of claims to cover it and surrounding territory, the first thing to be done is to locate a trail or road to the spot up which timber or supplies can be brought, either packed on burros or by wagon. Next, buildings must be put up, some for the miners to live in, others for a boarding house, superintendent's office, blacksmith shop, stable, wood house, and later, when the mine has reached the shipping stage, an ore house and an assay office.

In locating these buildings in a steep mountainous region like that of Idaho, care must be taken to place them out of the path of the avalanches or snowslides.

The configuration of the hillside must be studied. One well acquainted with the region will readily observe where snow is likely to collect and where not. The pathways of periodic snowslides are generally marked by an absence of timber or by a swath cut through the timber. Where timber is still standing thickly there is little fear. Where the mountainside is bare advantage may sometimes be taken of a location under an overhanging rock or one that would split or divert the slide when it came down. Choice of location may also depend, in a minor degree, upon where the sun strikes and remains longest in the winter months or from which way the prevailing wind blows.

On a steep hillside, such as is characteristic of the mountains of Idaho, a foundation for the house has to be quarried out of the slope, often a work of time and labor. A gang of carpenters is then sent for from the neighboring town. Miners and workmen have at first to live in tents or in rude box-like board buildings covered by a tent or wagon sheet. In the first stages of development there is of necessity considerable "roughing it," especially if the camp be located toward winter. In a few days, however, the carpenters have run up a substantial and fairly comfortable frame building of rough lumber, consisting, it may be, of two stories or one story and a loft, the size of the building being in proportion to the present size and capacity of the mine and the number of men to be employed.

The lower story usually contains two rooms—a larger one for a general dining room and a smaller one with a board partition between for a kitchen. The upper story or loft is fitted up with rows of bunks for the men to sleep in, either single rows or two sets one above the other like the berths in a Pullman car. The sleeping room is warmed in the winter by the stove pipe coming up from the kitchen or dining room fire below; to this pipe is sometimes added a drum.

Two men fraternally called "partners" usually occupy the same bunk. Each man brings his own bedding and blankets. In lieu of a mattress, hay or straw is brought in from the stable. Access to the loft is either by a ladder from the room below through a trap door or by a staircase on the outside of the building.

After the boarding house is built a small building, either annexed to it or apart, is made for the superintendent's office. This may be papered with terra-cotta building paper nailed to the wall with sheeting tacks. The furniture is simple. A table, a rough book case with a few books and papers, a chair or two, and a comfortable spring mattress bed. A shotgun or rifle and a few pictures adorn the walls. All is made as comfortable as circumstances will admit. The same may apply to the living room of the boarding house, the walls of which are often covered with pictures and made to look homelike. The roofs are covered with malthoid paper or corrugated iron roofing. While these other buildings have been going up the blacksmith has been busy setting up his forge and bellows close to the entrance of the mine and erecting a rough shed over it. Men need tools and drills sharpened from the very beginning. A temporary stable is put up for the horses, and mining begins in earnest, and the camp is established. If winter is approaching and

warns by one or two premonitory storms, a good supply of firewood must be laid in and stored in a wood house. Supplies, too, of provisions and other necessaries must be taken in wholesale for a winter campaign, for in a few weeks the road to the nearest town may be impassable except on snow shoes or occasionally on sleighs. Vegetables and other perishable goods may be stored in one of the drifts of the mine to prevent freezing. The cost of starting and equipping an average small mining camp is about $1,000.—From an article by Prof. Arthur Lakes, in Mines and Minerals.

THE FORERUNNERS OF THE AUTOMOBILE.

By F. M. FELDHAUS.

IN the Middle Ages a wagon of any kind was a rare phenomenon and loads were carried on the backs of horses and mules oftener than on wheels. Carriages for the conveyance of persons first appeared toward the close of the Middle Ages, and for a long time they were used only by princes, great ladies and invalids.

Not only did the proud spirit of chivalry, so intimately connected with riding and horses, retard the development of the more luxurious and convenient method of traveling, but the indescribably wretched condition of the roads and the heavy local imposts and tolls deterred all but the greatest merchants from using wagons for the transportation of goods.

But soon after the carriage first appeared we find it in its most modern form—the horseless carriage. The first one was built in imitation of a ship and driven by the wind. The oldest picture of such a craft

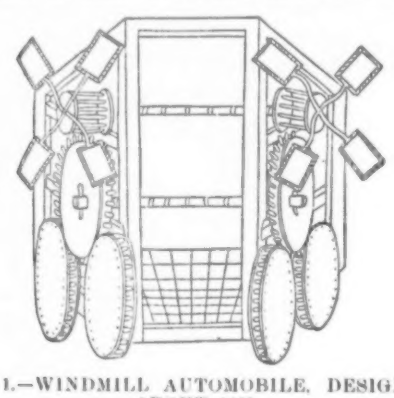


FIG. 1.—WINDMILL AUTOMOBILE, DESIGNED ABOUT 1460.

now extant illustrates an Italian manuscript on the art of war, written in 1430, and preserved in the Uffizi museum in Florence, but it is probable that the device is much older than this, for most of the illustrations of this manuscript are taken from a still earlier work, of which only fragments are in the possession of the Uffizi.

The next mention of a horseless carriage comes from Germany. The chronicles of the city of Memming record, under date of 1447, that a covered carriage, not drawn by horse, ox or man, traveled from the city gate to the market place and back, and its constructor sat therein. This is probably the earliest mention of a vehicle actually propelled by other than animal power. The often quoted passage written by the Franciscan monk, Roger Bacon, about 1250, is too vague to be regarded as anything more than the expression of a wish. Bacon says that a wagon can be made that will move with incredible speed, without being drawn by animals. What the famous old English friar regarded as incredible speed might appear now as incredible slowness, for no idea has changed more since his day than that of velocity.

The next notice of a self-propelling wagon is contained in the first illustrated book printed in Italy, a work on the military art by an engineer named Roberto Balturio. Here, among a great variety of fantastic military engines, we find the vehicle shown in Fig. 1. This was driven by windmills, the power of

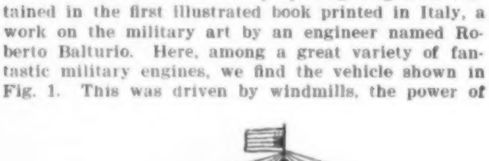


FIG. 4.—SAILING WAGON USED BY THE PRINCE OF ORANGE, ABOUT 1600.

which was transmitted to the wheels by gearing, and it was, therefore, a very different affair from the simple land ship of 1430.

Windmills originated, not in Holland, where they are now most abundant, but in Saxony, where they are mentioned in legal records in the ninth century. Before they appeared in Holland, in the fourteenth century, they had long been used in France and England, and had been introduced into Italy in 1332. The idea of the windmill automobile is probably much older than Balturio's book for in the infancy of printing the press offered no startling novelties. The remarkable perspective of this engraving, which shows the front and both sides of the vehicle, has the merit of giving

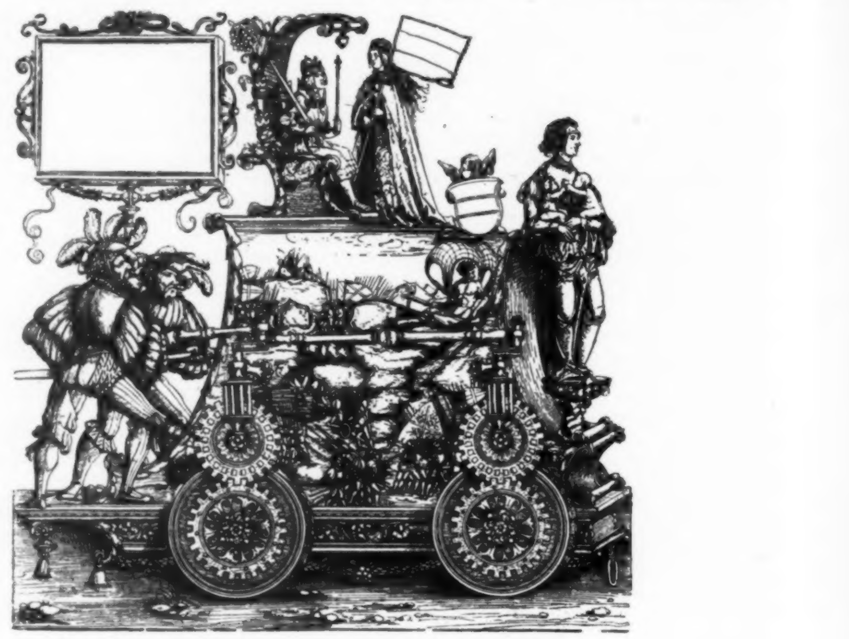


FIG. 2.—DESIGN FOR A TRIUMPHAL CAR.

(From a wood cut made about 1518.)

the layman a better understanding of the apparatus than he would obtain from a modern technical drawing. The windmills are absurdly small and probably are only intended to indicate the positions of the actual windmills.

We find the next mention of a horseless wagon in the disbursement records of the city of Antwerp, for the year 1479, when twelve pounds of silver were paid to

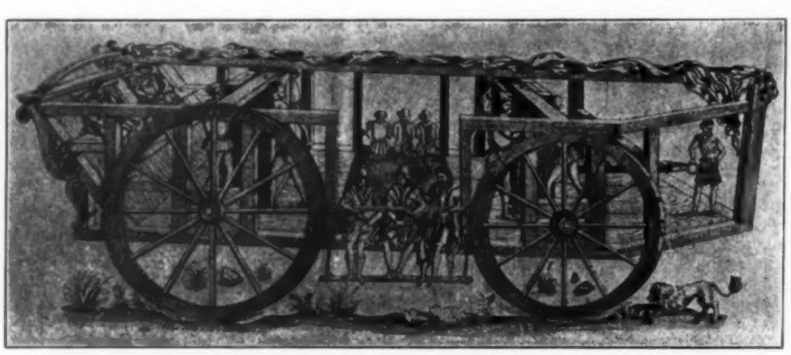


FIG. 3.—HOLZSCHUBER'S GREAT VEHICLE (1588).

Gilles de Dorn for constructing a wagon driven by concealed machinery. Of the character and appearance of this vehicle we have no information, but, as it was purchased by the city, we may assume that it was intended for use in war. It was probably a development of the windmill wagon, for Balturio's pictures had been reprinted as illustrations to a German translation of a military treatise by the Roman writer Vegetius, which was published in Ulm in 1472-5. This book,

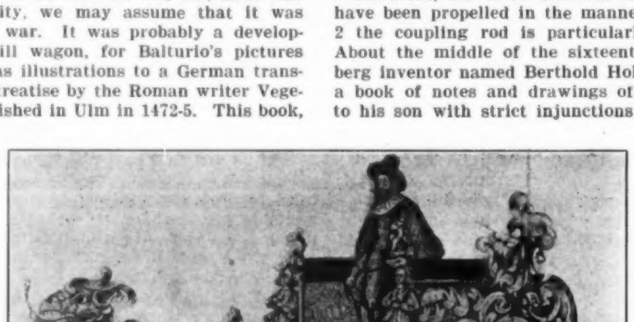


FIG. 5.—THE MYSTERIOUS DRAGON CAR, BUILT IN 1649.

of which only three copies are now known to exist, was the earliest German work on the subject, and the Antwerp engineer must have been familiar with it.

From the commencement of the sixteenth century come accounts of vehicles, driven by human muscular power, which may be regarded as intermediate forms between the automobile and the bicycle. The earliest mention of this type is found in Petrus Albinus's chronicles of the city of Pirna, now in the royal library in Dresden. The chronicler says that in 1504 a skillful mechanician constructed a wagon which he propelled by "screwing" (turning a crank or wheel). At its first public trial, in the presence of a "world of people," it stuck fast in the mud which happened to be very deep. Whether it was ever tried again, in more favorable conditions, is not stated.

We may, perhaps, form a general idea of the appearance of this vehicle from nine designs for self-propelling "floats" contained in a work on "Kaiser Maximilian's Triumphal Procession." One of these designs, greatly reduced, is shown in Fig. 2. The original woodcut blocks are still in the possession of the Austrian imperial family. They appear to have been made about 1518, but the vehicles, in all probability, were never constructed, for it is doubtful if one of them could have been propelled in the manner indicated. In Fig. 2 the coupling rod is particularly worthy of notice. About the middle of the sixteenth century a Nuremberg inventor named Berthold Holzschuber bequeathed a book of notes and drawings of mechanical vehicles to his son with strict injunctions never to show it to any one. The book is now in the Germanische Museum in Nuremberg. Fig. 3 shows one of the designs, made about 1558. It represents a huge vehicle with eight men at the cranks, eight passengers and a steersman. Holzschuher even suggests the addition of a parapet and cannon.

A century later two Nuremberg inventors made horseless vehicles that became celebrated. Meanwhile,

however, the land ship or sailing wagon had come into practical use. The first person who employed one was Prince Maurice of Orange, Stadtholder of the Netherlands. The mathematician Simon Stevin designed this famous vehicle, the appearance of which is made

FIG. 6.—FARFLER'S INVALID CHAIR (1650).

known to us by "broadsides," by a drawing on a map of Holland, and by a sketch, reproduced in Fig. 4, which a German traveler gives in his notes of a tour through the Netherlands. The wagon was built about 1599. According to credible reports it ran on the level beach at a speed of more than 30 miles an hour. This speed was extraordinary in those days, and it was not even attained by steam locomotives in the infancy of the railroad. Bishop Wilkins, writing in 1648, says that sailing wagons, "which have been used from immemorial times on the plains of China, and in Spain," can attain a speed of 100 miles an hour!

One of the Nuremberg inventors above referred to, Hans Hautsch, was a genius but a lover of mystery. His greatest invention, his claim to which is confirmed by a written statement of the great Leibnitz, was the air chamber for force pumps. He left grandiloquent illustrated circulars descriptive of this and of his automobile, but of the mode of action of the latter he merely says that it was driven "by clockwork." This is scarcely credible in view of the small amount of power obtainable from springs and the state of mechanical science in the middle of the 17th century. According to some accounts it was propelled by boys concealed in the interior. The speed of the vehicle was little more than a mile an hour. That it was merely an elaborate and useless toy appears from the circular from which our illustration (Fig. 5) is taken. The circular says: "The dragon rolls his eyes and spews water, and the angels raise and sound their trumpets. The dragon drinks water, beer, wine, mead or anything, though he prefers mead, and his tongue exudes all sort of perfumes."

This vehicle was probably constructed about 1649. It was purchased by Charles X. of Sweden, and a duplicate of it was subsequently acquired by the king of Denmark.

Hautsch's contemporary, the watchmaker, Stephan Farfler, had a very different object in view. He was a cripple and he invented the little vehicle shown in Fig. 6 for his own use. It is a matter of record that wheeled chairs which invalids could propel themselves were on sale in Nuremberg as early as 1650, but it is not certain whether Farfler or Hautsch was their inventor. Farfler's second machine, with four wheels, is still preserved in the Nuremberg library.

After this, interest in mechanical vehicles declined. Only two later examples deserve mention. One, shown in Figs. 7 and 8, was used, about the year 1690, by Dr. Richard, a physician of La Rochelle, in making his professional rounds. The other led to the invention of the first bicycle, or "Draisine."

In 1813 a young forester of Mannheim, named Von Drais, applied to the government of Baden for a patent on a "wagon propelled by its passenger," but his application was rejected on the ground that a similar vehicle was already in use. Thereupon Drais simplified his wagon until he had reduced it to a bicycle, for which he obtained a patent in 1818.

In the latter part of the seventeenth century the expansive power of steam became known through the researches of Guericke, Torricelli, Boyle, Papin, and others. Sir Isaac Newton appears to have been the inventor of the steam automobile. At least he attempted, at various times between 1663 and 1680, to drive a small wagon by the reaction of a jet of steam escaping from a boiler heated by a spirit lamp. Equally primitive and impracticable was the slightly earlier attempt of the German monk Kircher to propel a little vehicle by the expansion of mercury, which was heated and cooled alternately.

The steam road wagon was first brought into practical use by the French military engineer Cugnot, in 1769, though it had been suggested, in England, by

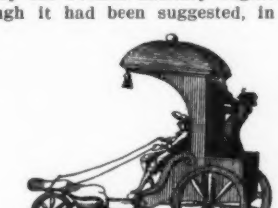


FIG. 7.—DR. RICHARD'S HORSELESS CARRIAGE (1690).

Savery, in 1700, and by Robison, in 1759. Cugnot's first machine was wrecked at its first trial, by colliding with a building, after the manner of automobiles. Two years later, with the financial assistance of the government, he built a second which is still to be seen in the Conservatoire des Arts et Métiers, in Paris. This oldest of genuine automobiles, the technical perfection of which reflects great credit on its inventor, is shown in Fig. 9. At the left we see the boiler and two steam cylinders, whose pistons act upon heavy driving wheels; in front of the driver's seat are the steering and brake levers, and the wheels are furnished with very modern anti-skidding devices.

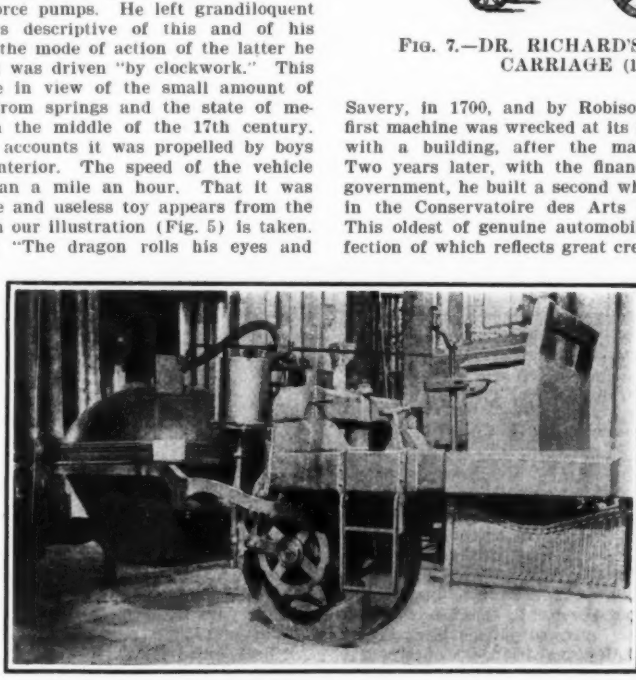


FIG. 9.—THE FIRST STEAM AUTOMOBILE (CUGNOT, PARIS, 1770.)

Napoleon was greatly interested in steam vehicles. He pensioned Cugnot, whose experiments had been interrupted by the revolution, and tried to adapt his invention to military uses. When Napoleon was elected a member of the French Institute he presented his first and only scientific paper, on a subject which is again of timely interest: "The Use of Automobiles in War."

Another interesting and almost forgotten historical detail is that in 1831 the British House of Commons, before making an additional appropriation for the construction of railroads, appointed a commission to examine the relative merits of locomotives running on rails, and steam road wagons. The commission reported in favor of the locomotive but the advocates of the road wagon endeavored to influence public opinion by establishing a regular automobile service between Gloucester and Cheltenham, a distance of 38 miles. Here the new vehicle came into competition with that arch enemy of speed, the post coach, in a race with which, in 1835, after a long newspaper war, the automobile won its first laurels. In the same year experiments were made with an electromobile, invented by Profs. Stratingh and Becker, of Groningen. The experiments failed, as did all subsequent attempts until the introduction of modern motors and accumulators within the recent years.

The inventor of the gasoline automobile was Siegfried Markus, of Vienna. A machine constructed by him in 1875, now in the possession of the Austrian Automobile Club, is shown in Fig. 10.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Die Gartenlaube.

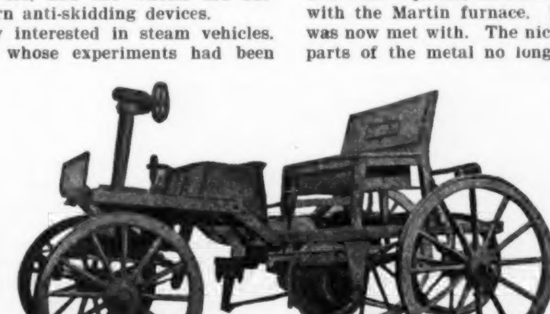


FIG. 10.—THE FIRST GASOLINE AUTOMOBILE (SIEGFRIED MARKUS, VIENNA, 1875.)

METALS USED IN AUTOMOBILE CONSTRUCTION.

ONE of our contemporaries asserts that a large manufacturer of the United States is fully impressed with the superiority of the automobile because of the quality of the steel employed. This opinion, moreover, is corroborated by the fact that many of the European works apply to our foundries for their crude material.

FIG. 8.—MECHANISM OF DR. RICHARD'S CARRIAGE.

Apropos of this we reproduce here a very interesting study that M. Partiot, engineer to the Société Parisienne de Cementation, has published in the Cycle et Automobile Industriels on the manufacture of nickel steels. Various categories must, says he, be distinguished among such steels, such as cemented steel, and steels that are indifferent to tempering or that become soft by tempering.

Nickel Cemented Steel.—It has been remarked that nickel antagonizes the cause, whatever it be, of the production of brittleness of cemented steel. This effect is very marked with a proportion of 2 per cent. A soft steel with this percentage of nickel, cemented and tempered, preserves in its central part the fibrous texture which characterizes a breakage after flexion and tension. Upon the advice of authoritative scientists, the manufacture was therefore begun of cemented steel containing about 2 per cent of nickel. Experiments were made with larger proportions, but it was of interest to obtain a steel of as slight cost as possible.

The security obtained with such pieces was very great, but various drawbacks were encountered. In the first place nickel steels, still more than the ordinary soft varieties, are subject to flaws. The rolling and forging therefore have to be done with the greatest care. In the second place it was found that the life of the metal was often shorter, after cementation and tempering, than in carbon steels. When large quantities were ordered many pieces were found having certain parts which refused to harden. What, then, had taken place?

The first nickel steels used in the experiments were prepared in the crucible. When an industrial production was required, an endeavor was made to obtain it with the Martin furnace. But an unforseen difficulty was now met with. The nickel liquified, so that certain parts of the metal no longer contained a trace of it, while other parts were pure nickel. It is useless to say that cementation produced no effect upon such parts. There is a third inconvenience, which is very marked in certain cases, and which renders the advantage of nickel steel illusory, and that is the variations of volume produced in the annealing and tempering. The brittleness produced in carbon steels by cementation

can be greatly diminished by means of a proper thermic treatment, which consists in principle in two annealings followed by tempering at a suitable temperature. Now, a single tempering almost always produces deformations, and two produce twice as many. In nickel steels with a single tempering it was hoped that we should have half as many. Now, this is far from being always the case. Nickel steel very often dimishes in volume on being tempered, and that, too, very greatly. It is not rare to see the bore of a sliding gear, for example, widen by a millimeter after cementation and tempering. A bar of soft nickel steel sent to one of the best mechanical works in Paris in order to have a hole countersunk in it came back in a sorry condition. The workman having inadvertently exceeded the diameter of the bore by a tenth of a millimeter, the engineer, in order to save the piece, tried to contract the aperture by tempering the piece, a process that often succeeds with soft steel. To his great amazement, after tempering, the bore of 28 millimeters had increased by two millimeters. This mishap was due, perhaps, to the fact that metallurigical works, accustomed to forge soft or other carbon steels, are not used to nickel steel and do not forge it at the temperature that it requires.

Without entering into long explanations, we know that what is called the transformation point of a steel is the temperature above which the metal must be tempered in order that it shall harden. This definition is not exactly correct, but let us accept it for what it is worth. Now, we know that the addition of nickel lowers the point of transformation of a steel. This is as much as to say that at the same temperature (at 900 deg. C., for example) a nickel steel is softer than a corresponding carbon one. Therefore, if we forge them in the same manner and at the same temperature, the nickel steel will be harder and denser than the carbon. As the annealing destroys such hardness, it will cause the volume of the nickel steel to vary more than that of the other. Steel works should therefore be requested to begin the forging or rolling of nickel steel at a lower temperature. Then the blocks or bars should be annealed after forging or rolling. And, as the manufacturer cannot see whether the steel works have done the work properly, he should perform it himself. Still more than when it is a question of carbon steel should he anneal his pieces before finishing them. He would do better still to temper as well as anneal them, but he would not completely avoid the inconvenience spoken of. For the change of volume is not an exaggeration of the same phenomenon occurring in soft steel; it takes place in the contrary direction in the case mentioned. Therefore, here again it is by repeated trials only that information can be gained. Select your steel producer and make experiment after experiment till success crowns your efforts.

The ordinary proportion of nickel in cemented steel is from 2 to 3 per cent. If this proportion increases, the price advances, and moreover, the steel becomes hardened and no longer has the same resistance to flexion after it has once been cemented and tempered.

Certain steel works recommend a 6 per cent nickel steel, to which they ascribe the property of resisting deformation when tempered. Such property is claimed also for certain mangano-silicious steels. We do not know upon what theoretical considerations such pretention is based.

A certain steel works has put upon the market an extremely interesting nickel steel, which exhibits, on cementation without tempering, a hardness analogous to that of a steel cemented and tempered. This property, which had been already remarked in certain quaternary steels, seems to be very important. There is no tempering, and consequently no deformation, and no softening in case of accidental heating. This steel appears to be destined for a great future; but manufacturers must be put on guard against various dangers, viz.: (1) like other nickel steels, it may exhibit flaws; (2) the deformations may prove important, especially if the pieces are not annealed before finishing; (3) the cooling, although slow, produces tensions which may deform the piece. Thus a cemented plate may become distorted, and, if straightened while hot, may become distorted anew on cooling.

Finally, the hardness is not after all comparable with that of cemented steels. It may be increased by tempering the piece, but the center also becomes slightly tempered. The hardness would be very great, without tempering, if the steel contained exactly 7 per cent of nickel; but as is well known, nothing is more difficult than to obtain a steel having exactly a determinate composition, especially in the Martin furnace.

Other Steels that Take a Temper.—Steels are still employed having a mere trace of carbon and containing from 2 to 6 per cent of nickel, and which are tempered in order to increase their resistance. In this order of ideas, the chrome nickel steels are more employed and more interesting.

Steels Indifferent to Tempering.—These are steels with a mean proportion of nickel within limits that vary according to the proportion of carbon. Such steels, which are nearly indifferent to annealing and tempering, are difficult to forge and work. They can be softened only by annealing under determinate conditions which vary when the composition of the steel varies somewhat; that is as much as to say that the use of them is not very practical. Consequently they have been nearly discarded.

Nickel Steels Softened by Tempering.—These are steels that contain a large proportion of nickel, that are relatively soft, and that are characterized by their entire want of fragility. They are, besides, nearly inoxidizable. Finally, their coefficient of expansion decreases, and at a certain proportion, it approaches 0.

Extensive use of these steels is made for automobile valves, and steels having a small proportion of carbon and containing from 32 to 33 per cent of nickel are recommended by preference.—Translated from the French of E. Partiot in La France Automobile for the Scientific American Supplement.

MANGANESE-BRONZE AND ITS MANUFACTURE.*

Manganese-bronze made its appearance on the market about the year 1876, and soon after aluminium-bronze began to be sold at a price which placed it within the reach of the marine engineer or other designer. For a number of years these two alloys, made by competitive companies and sold for the same purposes, became antagonistic to one another and many heated discussions took place in the trade papers about the relative value of the two alloys. Manganese-bronze finally won, and its use has increased until to-day its name has become almost a household word.

Manganese-bronze has practically driven aluminium-bronze out of the market, or to such an extent that the disparity in the quantities used is very great. This condition has taken place not because of the superiority of manganese-bronze over aluminium-bronze, but because it is cheaper (containing as it does nearly half zinc) and may be more easily cast. Unfortunately, aluminium-bronze is very difficult to cast in large sections. The extreme shrinkage, the large amount of dross, and the cost all militate against the extensive use of this valuable alloy. When a good casting of aluminium-bronze is made, however, it is superior in every way to manganese-bronze. I do not say this because I am prejudiced in any way, for I have had fully as much to do with one of these alloys as another; but for the reason that I firmly believe aluminium-bronze has met with defeat, not because of its lack of strength, not from unsuitability for all the work which manganese-bronze will do, not on account of its excessive cost, but for the reason that no one has yet mastered its casting so that successful castings may be continuously turned out. When this has been done, and at some future time it will be accomplished, aluminium-bronze will replace manganese-bronze as it has been replaced itself.

HISTORY OF MANGANESE-BRONZE.

Manganese-bronze is a misnomer. The uninitiated at once believe that it contains a large amount of manganese. The initiated know that it does not. It is not rare, indeed, to find manganese-bronze castings which answer specifications which contain no manganese at all. In fact, it is rare that over a few hundredths of a per cent of manganese is found in manganese-bronze. The object of the manganese is not to act as an ingredient of the alloy, but as a carrier of the iron which must be present in the mixture to obtain the necessary strength and elastic limit.

As the manganese-bronze of commerce is known to-day, and as it exists on the market, it represents the invention of Perceval Moses Parsons, of London, England. The first record which we have of such an alloy is embodied in British Patent No. 482, of February, 1876.

The only claim which Parsons made was the introduction of the iron into the bronze through the agency of the manganese. The simple presence of iron in bronzes could not be claimed by him, as it had been known long before this time that iron imparted strength to copper and zinc or copper and tin alloys. The well-known sterro-metal, Aich-metal, and several others of the same nature all contained iron. Parsons, however, did not attempt to claim such alloys, but the method of introducing the iron. In this his invention is novel.

As far as the preceding invention is concerned, I will say that the alloy which was produced by following its direction must have been disappointing as far as the copper and zinc alloys were concerned, because no one is able to cast alloys so high in zinc in sand molds with any success without other additions. In fact, Parsons's bronze, made after the preceding formula, was no better than the old sterro-metal which had been tried for sand casting purposes and found wanting. Parsons apparently realized that, while the iron which was introduced made the copper and zinc alloys very strong, the presence of so much zinc rendered it impossible to make sound sand castings. When it is known between 40 and 45 per cent of zinc was added to the alloy, the difficulty of casting will readily be appreciated.

For some time, therefore, Parsons confined his attention to the copper and tin alloys to which the iron had been added, and propellers and similar forms of large castings were made from it. The alloys of copper and zinc with the iron content were used for casting in metal molds, for forging, and for rolling into sheet. No attempt was made to cast them in sand until apparently it was realized there was a possibility that some addition was necessary for the successful casting of the copper and zinc alloys. This addition was found in aluminium. In 1888, Parsons was allowed a patent for the addition of aluminium to the alloys enumerated in his former patent.

From this date on, the aluminium made it possible to successfully cast the alloys of copper and zinc in sand, and the copper and tin mixture was abandoned. It is without qualification that I am able to say the success of manganese-bronze, as made to-day, lies not so much in the iron which it contains, but in the aluminium. Before it was known that aluminium imparted a good sand-casting quality to the copper and zinc alloys high in zinc, manganese-bronze could scarcely be called a success.

After Parsons had been allowed his patent in Great Britain, one was granted him in the United States. This patent, No. 206,604, July, 1878, manufacture of alloys of manganese, P. M. Parsons, London, England, is a counterpart of the British Patent No. 842 of 1876. It will be seen that both of these patents have now expired.

THEORY OF MANGANESE-BRONZE.

The manganese-bronze of commerce is now practically confined to two grades: First, a mixture for rolling into sheet, or drawing into wire or tubes. This grade is also used for forging. As this mixture contains no aluminium, it cannot be cast in sand. The difference between this, the rolling mixture, and the mixture for sand casting is in the absence of aluminium and a slightly less zinc content. Second, a mixture for sand casting. This sand-casting mixture is the one extensively used for the manufacture of propellers and other well-known appliances. This sand-casting mixture contains aluminium to impart the necessary sand-casting qualities to it, and without it the castings could not be made. This sand-casting mixture, however, is not suited for casting in metal molds, on account of the presence of aluminium.

In order to indicate the composition of these two grades of manganese-bronze, I will give the results of analyses of samples which were made by the inventor. The results which I have obtained are as shown in the accompanying tables.

ANALYSIS OF PARSONS'S MANGANESE-BRONZE SHEET.

Sample.	No. 1.	No. 2.	
Copper	60.27	60.02	per cent
Zinc	37.52	37.70	" "
Iron	1.41	1.53	" "
Tin	.75	.72	" "
Manganese	.01	.02	" "
Lead	.01	.01	" "

ANALYSIS OF PARSONS'S MANGANESE-BRONZE NO. 2.

(Ingots for Sand Casting.)

Sample.	No. 1.	No. 2.	
Copper	56.11	56.23	per cent
Zinc	41.34	41.16	" "
Iron	1.30	1.41	" "
Tin	.75	.68	" "
Aluminium	.47	.51	" "
Manganese	.01	none	" "
Lead	.02	.01	" "

In theory, the functions of the various ingredients are as follows: It has been found that the strongest copper and zinc alloy has the composition of about 55 per cent of copper and 45 per cent of zinc. The addition of iron to this alloy not only raises the strength, but the elastic limit as well. By adding the tin to this mixture, the elastic limit is well defined and the strength increased. If too much tin is present, however, the alloy becomes brittle. From 0.50 to 0.75 per cent of tin is all that is required. The aluminium is added to the sand-casting mixture for rendering it possible to cast the alloy in sand. Without it this would not be possible. The small quantity of lead which is present is introduced from the zinc. It will be noted that the amount of lead in both the sheet and the ingot is very small. This is brought about by the use of refined spelter. It has been found that common spelter contains enough lead to injure the strength of the alloy, and therefore, when the very highest strength is desired, together with the maximum elastic limit and elongation, only a refined spelter should be used.

The manganese in the alloy serves one purpose only: To introduce the iron. It acts as a carrier of the iron, and without it the iron would not alloy with the copper. All brass-foundrymen know how difficult it is to thoroughly incorporate iron with copper or brass. If metallic iron is melted along with copper or brass, part enters the alloy and becomes chemically combined, and the remainder separates in pellets or nodules of the hardness of steel. These nodules are the source of much trouble in brass, as they injure tools to an alarming extent. By the use of manganese and iron together, the iron may be made to alloy perfectly with the copper, or copper and zinc, without any danger of the steel-like nodules separating. This is the real function of the manganese, and it has no other use. If added in large amounts, it hardens the mixture, but not nearly as much as the iron. At the same time the mixture is deficient in elastic limit. The iron seems to be necessary to produce this.

The manufacture of the ingots of manganese-bronze is the first step. It has become a well-established fact that the mixture must first be poured into ingots and then remelted and poured into castings. The first melt does not give good castings. I will describe each step in the manufacture of the manganese ingot. The first process is the production of the "steel-alloy," as it is called, by means of which the iron and tin are introduced into the alloy.

MAKING THE "STEEL-ALLOY."

Ferro-manganese is used in the manufacture of steel to promote soundness. It consists of about 80 per cent of manganese, about 14 per cent of iron, and about 6 per cent of carbon. Other ingredients, such as sulphur, silicon and phosphorus, are present in small quantities. This ferro-manganese is used in the manufacture of manganese-bronze, and it is the base of the whole operation. Spiegeleisen is an alloy of about 80 per cent of iron and 20 per cent of manganese, and may likewise be used for making the "steel-alloy," but the ferro-manganese is readily obtained and is generally used. The ferro-manganese is found on the market

* Abstract from an article by Edwin S. Sperry in The Brass World.

in lumps and is easily broken. It is not expensive and as so little is used the cost is of little importance.

The ferro-manganese is melted with pure wrought iron. This wrought iron should be in small pieces, and the best form is in small pieces of rods which have been cut. As Norway iron is the purest form of iron on the market, it is to be preferred, although any other form of wrought iron will answer. I cannot recommend fine iron wire, as the oxidation is too great in melting. I have been accustomed to use half-inch Norway iron rods which have been cut into small bits so that the pieces will pack well in the crucible. The iron and manganese alloy is made as follows:

Wrought Iron	18 pounds
Ferro-Manganese	4 pounds
Tin	10 pounds

The iron and the ferro-manganese are put in a graphite crucible together and covered with charcoal. They are then melted as rapidly as possible. It is well to cover the crucible with a lid, as the melting then proceeds more rapidly. The fire must be urged to its utmost capacity to melt the iron and the ferro-manganese, and when this has been done an iron rod (previously made red-hot to avoid chilling the metal) indicates that all the lumps have become liquid, the tin is added and the whole stirred. A plumbago stirrer is preferable to the iron, as there is then no danger of chilling the liquid metal.

When all has been melted, the metal is poured into small strip ingots so that they may be readily broken up. They will be found to be quite brittle, so that no difficulty will be experienced in breaking them. This "steel-alloy" which is thus produced is used for melting with the copper.

MAKING THE MIXTURE.

The mixture for the manganese-bronze is made as follows:

Ingot Copper	56 pounds
Bertha Zinc	43 pounds
"Steel-Alloy"	2 pounds
Aluminium	½ pound

One ingot (or about 15 pounds) of the copper is put in a crucible and melted under a good covering of charcoal. The heat of the copper should be brought to a bright red. Now add the "steel-alloy" and stir. If the "steel-alloy" does not melt, the heat must be raised until it melts and alloys with the copper. When this is done, add the aluminium. When the aluminium melts and alloys with the copper considerable heat will be generated by the combination. This will serve to liquefy any of the "steel-alloy" which may not have alloyed with the copper. The whole should be thoroughly stirred at this point.

The remainder of the copper is now added and allowed to melt, and, after stirring again, the zinc is added. The whole is now once more stirred and the metal then poured into ingots. Care should be used not to overheat the copper so that there is a large loss of zinc. I have made allowance in the preceding formula for a waste of one and one-half per cent of zinc in two meltings so that the sand casting will contain approximately 56 per cent of copper.

The preceding mixture will be resolved into the following percentages after the 1.5 per cent of zinc which was allowed for waste has been deducted:

PERCENTAGE-FORMULA FOR MANGANESE BRONZE.

(For Sand-Castings.)

Copper	56.00
Zinc	42.38
Iron	1.25
Tin	.75
Aluminium	.50
Manganese	.12

As previously stated, a sufficient quantity of zinc has been added to allow for the waste of two meltings; but in case the metal is melted more than this number of times, 1 pound of zinc should be added every time the melt is made. This will compensate for a moderate loss. If the bronze is allowed to overheat, from 2 to 3 pounds to 100 pounds of metal will have to be added.

CASTING IN SAND.

While the making of manganese-bronze is the most important part, it is necessary that great care is bestowed upon the casting of it. Unless this is done a good ingot metal will never produce strong castings. The most particular part of the casting is the melting.

Let me say at the start that it is very poor policy to have the metal ready before the molds are finished. In this manner metal is allowed to "soak" in the fire and is ruined. In melting, the metal should be well covered with charcoal and not allowed to become any hotter than is necessary for the pouring of the casting. It is a mistake to believe that an overheated metal can be brought down to the right heat by means of gates and still have it as good as when it is not allowed to overheat. Metal of this kind will never give castings with a high tensile strength.

As manganese-bronze contains so much zinc it melts easily, and it is very easy to overheat it. For large castings the metal is ready before it "flares." In this instance, the surface will flare very slightly when disturbed with a skimmer. In this condition the metal is ready for pouring, and one will be surprised how much better results may be obtained than with overheated metal.

For small castings it will frequently be necessary to have a slight "flaring" of the zinc upon the surface of the melted metal in order to make certain that the castings will run. It is surprising though, how "dull" the manganese-bronze may be poured and still have the casting run. The best results are invariably obtained by not allowing the metal to get any hotter than is necessary for the "running" of the casting. Metal poured as "dull" as possible is invariably the best.

The use of manganese-bronze in propeller wheels is now its largest consumption. Here it is necessary that a strong, tough alloy be used, and one which will resist the action of sea water. Manganese-bronze propeller blades are now made very thin, so as to save weight.

Most propellers are now cast with separate blades, as this method allows broken blades to be replaced. The casting and molding difficulties are likewise decreased.

TEST BARS.

As manganese-bronze is a strong metal and is used to meet the special requirements that are found in large engineering problems, nearly all of the castings which are made are required to come up to specifications. Test bars made from the mixture previously given and cast in green sand have repeatedly given the following:

Tensile strength	70,000 lbs. per sq. in.
Elastic limit	30,000 lbs. per sq. in.
Elongation in 6 inches	18 per cent
Reduction of area	26 per cent

I have given the preceding tests merely to indicate what can be accomplished, as space will not now allow me to go into greater detail about the casting of test bars. In a later paper it is proposed to take up the casting of manganese-bronze and explain it more fully. This paper is intended to enlighten the reader upon the making of the ingot metal.

MANGANESE-BRONZE SHEET AND FORGINGS.

The mixture which is used for this purpose is practically the same compositon as that which is used for sand casting except that it contains no aluminium. The copper is also increased until the mixture is practically Muntz metal. This is necessary, in order that the metal may not be too stiff when rolled.

The following mixture may be used for rolling into sheet, forging, etc.:

MIXTURE FOR MANGANESE-BRONZE SHEET.

Copper	60 pounds
Zinc	39 pounds
"Steel-Alloy"	2 pounds

The "steel-alloy" is melted with one of the copper ingots in the same manner as before, and then the zinc is added. In this manner it is possible to avoid the excessive loss of spelter. As this mixture contains no aluminium, it need not be melted twice, and castings may be poured from it at once. The casting of it in iron molds is carried out in the same manner that brass is cast. Allowance is made in this mixture for a loss of one per cent of zinc. If great care is not taken to keep the loss of spelter down in casting this mixture, the copper will increase to such an extent that hot-rolling cannot be done upon the metal.

The mixture for sheet rolling in percentage gives the following:

Copper	60.00 per cent
Zinc	38.00 per cent
Iron	1.25 per cent
Tin	.65 per cent
Manganese	.10 per cent

This mixture may be rolled both hot and cold and may also be used for forging purposes.

To control the hardness of manganese-bronze the "steel-alloy" may be varied. If a mixture with more elongation is needed then less of the "steel-alloy" is added. More gives a harder alloy and one with less elongation and reduction of area.

The manganese in the mixture is usually oxidized out in one or two meltings, it not before. This accounts for the small percentages which are found in commercial manganese-bronze. The manganese may be shown in an analysis of the manganese-bronze, but it has done its work in deoxidizing the copper and allowing the iron to become incorporated in the alloy. In manganese-bronze as made at the present time, manganese has no other action.

RESEARCHES ON METALS OF PLATINUM GROUP.*

By PROF. HENRI MOISSAN.

THE industrial method which is employed at present for separating the different metals of the platinum group is about the same as is indicated by Wollaston, but the fusion of platinum in a chalk furnace by an oxygen and coal-gas blowpipe as shown by Deville and Debray makes it easy to work with platinum and its alloys. We can thus melt platinum while avoiding the presence of silicon and can study the fusion and the volatility of different metals of this group. These savants showed that palladium is more fusible than platinum and that rhodium and iridium can be melted thus, but with greater difficulty. This process was used in obtaining numerous specimens of platino-iridium prepared by the International Metric Commission. Since then, Joly and Vèzes were able to melt osmium, which was for a long time thought infusible, by using the electric arc. Ruthenium has also been fused, and is but slightly volatile.

The temperature of the oxy-hydrogen blowpipe is not high enough to melt these two metals. In the case of refractory and easily oxidized metals as osmium and ruthenium the blowpipe could no longer be used. The combustion of hydrogen in oxygen gives water vapor, or an oxidizing medium which intervenes in many reactions. On the contrary when we use a strong electric arc in the midst of a chalk furnace, we find given off great volumes of hydrogen, calcium vapors, some oxide of carbon and thus we have a reducing medium. Moreover, as the heat of the arc is much higher, we can go further in our researches. The following experiments have been made with the ordinary form of Moissan furnace, consisting of a chalk block, hollowed to take a carbon crucible and covered by a second block. Two carbons run in at the sides form a strong arc above the crucible.

Osmium.—We place 100 grammes (3.4 ounces) of osmium in the crucible, using a cold tube to condense the metallic vapors. The first experiment was made with a current of 500 amperes and 110 volts and lasted four minutes. On the cooled tube was found a small quantity of osmium distilled in the form of drops, but the metallic fragments placed in the crucible did not take the liquid state. Their upper part was only rounded off as they commenced to melt. With 600 amperes during 5 minutes the metal partly melts, but a good portion is volatilized, and 16.5 grammes (0.58 ounces) distilled off. This experiment was repeated with 150 grammes (5.1 ounces) of osmium using an arc of 700 amperes for five minutes. Here the osmium is all melted and boils, and we volatilize some 29 grammes (1.1 ounces) of it. The metal remaining in the crucible has the aspect of a brilliant mass, and is brittle. It contains very good crystals of graphite, and we find nearly 4 per cent of the latter. On breaking the metal we observe in the interior several geodes containing microscopic octahedral crystals of regular form. On the cold tube we collect numerous drops whose surface is brilliant or bluish, also flat crystals often like small cubes.

Ruthenium.—We use 150 grammes (5.1 ounces) of the metal and heat for three minutes with 700 amperes. The metal melts well, then boils and we distill 16.5 grammes of it (0.58 ounce). The metallic mass in the crucible contains 4.8 per cent of graphite. In the chalk we find minute cubical crystals. In another experiment we melt the same quantity of the metal at 500 amperes, and volatilize 10 gr. (0.54 oz.). The metal condensed on the cold tube and separated from the volatilized chalk by acetic acid shows numerous minute spheres of an old-silver aspect and some thin plates covered with microscopic crystals. The melted chalk is colored gray and even black by the ruthenium vapor and on the electrodes we collect metallic globules of a garnet red and a black powder. This metal boils less easily than platinum. Its boiling point lies between platinum and osmium.

Platinum.—We already showed that platinum easily enters into ebullition in the electric furnace. In the present case 150 grammes (5.1 ounces) were heated in the crucible with a current of 500 amperes for five minutes, and 12 grammes (0.41 ounces) were volatilized. The ebullition of platinum here takes place with a great regularity. The liquid metal distills as easily as boiling water. After cooling, the platinum in the crucible contains graphite. The metal shows geodes coming from gas bubbles, and these are sometimes lined with small metallic crystals. On the graphited sides of the carbon crucible we often find a gray layer of small globules and small microscopic cubical crystals. The matter condensed on the cold tube, after treating with acetic acid, contains numerous droplets, and sometimes small brilliant crystalline plates. The chalk around the crucible is colored a dark gray and the inside of the furnace shows large drops which have crystalline points.

Palladium.—This metal, which has been melted in the air and coal-gas blowpipe, has been volatilized in the oxy-hydrogen blowpipe. In our experiments we use 23 grammes (0.78 ounces) and heat it with 500 amperes and 70 volts for two minutes. The metal melts rapidly, then boils, and we easily volatilize 3.2 grammes (0.11 ounces) of it. The mass left in the crucible has been saturated with carbon and the surface is covered with graphite crystals. Around the crucible the chalk is colored black. It contains numerous metallic spheres often seeming like a cluster of crystals. Inside them we find geodes filled with small crystals. On the cold tube is obtained a fine black powder containing numerous globules and microscopic crystals. In another experiment we find that when a 150-gramme (5.1 ounce) mass of melted palladium saturated with carbon is removed from the electric furnace and let cool, graphite rises to the surface and covers the latter with superposed flat crystals. Then when a crust is formed we hear a series of cracking noises. The surface of the metal splits up and here and there appear brilliant drops of the melted metal and crystalline growths which are darker in color. The surface of the metal has a bluish color with iris reflections and presents various crystallizations. On the cold tube we find a mass of very small crystals mixed with metallic globules.

Iridium.—In this experiment we heat 150 grammes (5.1 ounces) for five minutes with 500 amperes and 100 volts. When it becomes liquid the metal dissolves the carbon of the crucible and distills regularly. In five minutes we are able to distill 9 grammes (0.5 ounce) of it. On cooling it becomes hard, but can be filed. The surface is sometimes crystalline. The metal contains 2.8 per cent of graphite, and can be broken under a shock. On the surface of the tube is collected a metallic layer of a blue color, which is formed of minute drops and microscopic crystals.

Rhodium.—The first experiment in distilling this metal was made with a carbon-tube furnace. Five grammes (0.17 ounces) of rhodium were placed in a graphite trough and above it lay a copper tube carry-

* Paper read at Académie des Sciences.

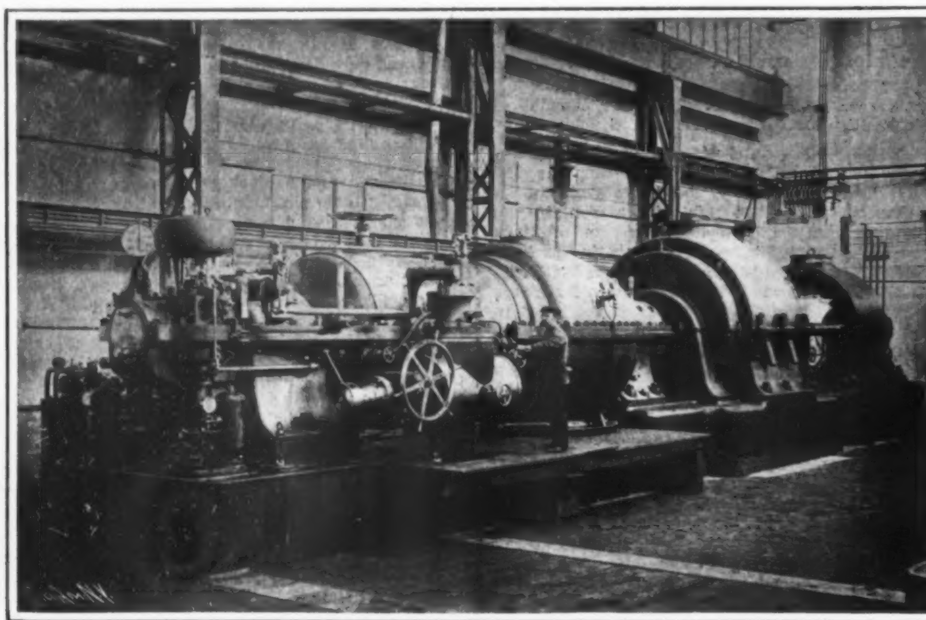
ing a water current and lying along the main carbon tube. The lower part of the latter is heated by the arc in the chalk furnace. After thirty seconds (using an arc of 500 amperes and 110 volts) the metal melted, boiled, and we observed blue vapors depositing on the cold tube. After the experiment we find on the tube a brilliant metal sometimes having a bluish luster, covered with fine drops and small prismatic crystals. Around the trough and on the carbon tube we also find small groups of crystals. In another case the metal was heated in a crucible, when the latter broke and the liquid metal ran down into the molten chalk. This rhodium appeared in a refined state and gave a brilliant metal which could be easily filed. Another heat was made with 150 grammes (5.1 ounces), and in five minutes we find that 10.2 grammes (0.34 ounce) distilled off. In the latter case the bottom of the ingot was covered with fine crystalline needles of the metal.

The conclusions to be derived from the above experiments are that all the metals of the platinum group are rapidly melted and then enter into ebullition in the electric furnace with currents which vary from 500 to 700 amperes at 110 volts. Using 150 grammes (5.1 ounces) of the metal, the fusion is carried out in one or two minutes, and the regular ebullition is reached before four minutes. On the water-cooled copper tube above the crucible we collect metallic globules, crystalline plates, and oftenest a layer of very small crystals seen only in the microscope. All the liquid metals dissolve carbon, and then abandon it on cooling in the form of graphite. The metal which is the most difficult to distill by the electric furnace is osmium. Palladium is easier to melt than platinum, but does not seem to be more volatile than the latter or rhodium.

A STEAM TURBINE OF 10,000 HORSE-POWER CAPACITY.*

By DR. ALFRED GRADENWITZ.

STEAM turbines are being constructed in increasing sizes, and two units which are being installed at the Rhenanian Westfalian Electricity Works of Essen, Germany, are the largest stationary machine sets ever built in Europe. By the courtesy of Messrs. Brown, Boveri & Co., who are the constructors of these interesting engines, we are enabled to illustrate one of the sets in question which has been completed and is ready for operation. This Brown-Boveri-Parsons steam turbine is direct connected to a three-phase, 5,597-kilowatt alternator of 7,500 horse-power output, generating 5,000 volt, 50 cycle current, and on the same shaft farther from the turbine is a direct current generator designed for an effective output of 1,697 kilowatts, or 2,250 horse-power, at 600 volts. An exciter machine, 61.6 kilowatts and 220 volts, serving for the excitation of the fields of both these generators, is likewise direct connected. The unit rotates at a speed of 1,000 revolutions per minute.



A SINGLE UNIT OF THE ELECTRIC PLANT AT ESSEN, GERMANY.

A 10,000-horse-power steam turbine is direct connected to a 7,500-horse-power, 3-phase alternator and a 2,250-horse-power direct-current dynamo.

The turbine is to be operated with steam at 154 pounds, the pressure in the boilers being 162 pounds, and at an initial temperature of 482 deg. F., which later increases to 572 deg. F. The steam turbines are connected to a central condensing plant, producing a vacuum of 85 deg. The governor is of a well-known type and keeps the angular speed constant to within 1 per cent for a change of 20 per cent in the actual load. The maximum variation in the number of revolutions between running at no load and at full load is not to exceed 5 per cent. The governors are provided with an attachment allowing the number of revolutions to be altered by hand 5 per cent in either direction during the operation. The regulation of the turbine is such that the alternator can be readily connected in parallel to the existing generator driven with any loads and also at no load.

The turbine is of the single cylinder type and possesses only two bearings, one of which has been designed as a double bearing. This also, together with a double bearing at the other end, serves for the alternator. The second double bearing, together with an external bearing, carries the direct current generator, while the exciter machine is placed beyond the latter. The number of lubricating points is thus reduced to six, and these are fed in the usual manner by circulating a continuous supply of oil under pressure. The total length of the unit is 64.567 feet, of which 30.84 feet is the length of the turbine, including its bearings, steam-inlet, and governor. The alternator has a length of 19.16 feet, and the direct current generator 14.18 feet. The ground plate is 8.2 feet in breadth. The maximum width of the set in the neighborhood of the governor is 10.5 feet while the point of maximum height, the upper edge of the alternator housing, is about 13.12 feet above the floor of the engine room. The vane system of the turbine shaft is 8.2 feet in length, the maximum diameter in the last expansion stage being 5.9 feet, inclusive of the vanes. The weight of the turbine including the ground plate but excluding the dynamo is about 235,890 pounds, while the main generator weighs 100,300 pounds, and the exciter machine exclusive of the bearings and shafts 7,500 pounds. A Westphalian mining company intends putting in operation another 10,000-horse-power turbine of the Parsons type in the near future.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

SUBMARINE CABLES.

GERMANY EXTENDING HER LINES OF COMMUNICATION.

CONSUL LIEFIELD, of Freiburg, reports that Germany has completed the laying of a new cable extending from Shanghai to Yap in the Caroline Islands, a distance of over 2,000 miles. The cable is laid at the greatest ocean depth of any in the world, and closes a gap that makes it the first continuous non-English line to encircle the globe. The consul also gives some interesting information as regards other cable lines. He says:

"The year 1905 has been for the German cable industry a very significant one, for it not only gave to Germany a great many new cables, but the advantages and advancements made in sea cable technic can be said to have been in every respect first class. It is claimed that the rapidity and precision with which the newest German cable from Shanghai to Yap, in the Caroline Islands, was laid, which had been finished and ready for use on November 1, are unexcelled.

"The number of German cables which have a length of over 62 miles has been increased through this new cable to thirteen and are as follows: Emden-Borkum-Lowestoft (England) (1871), 261.5 miles; Hoyer-Westerland-Arendal (Norway) (1879), 293.3; Emden-Valentia (Ireland) (1882), 984.8; Emden-Borkum-Vigo (Spain), (1894-96), 1,304.2; Sassnitz-Trelleborg (Sweden) (1898), 72.7; Emden-Borkum-Horta (Azores) New York (1900), 4,790.1; Tjintau-Tschifu (China) (1900), 283.9; Tsintau-Shanghai (China) (1900), 436.2; Emden-Borkum-Bacton (England) (1901), 288.9; Emden-Borkum-Horta (Azores) New York (1903), 4,911.9; Konstanza (Roumania) Constantinople (1905), 213.1; Menado (Celebes) Yap (Caroline) Guam (Ladrones) (1905), 2,018.8; Shanghai-Yap (Caroline) (1905), 2,229.4.

"Of these the Emden-Valentia and Emden-Borkum-Horta belong in common to Germany and England; Sassnitz-Trelleborg in common to Germany and Sweden, Emden-Borkum-Vigo, and Emden-Borkum-Horta to the German Atlantic Company; Koustanza, to the East European Company; Menado-Yap and Shanghai-Yap to the German-Netherlands Company, and only the remainder can be considered as the sole property of the German Empire. The Emden-Valentia was formerly the only telegraphic communication with America, but ceased to be used when the real German Atlantic cables, Emden-Borkum-Horta and Tjintau-Tschifu, were completed. Besides these large ocean cables there are a great number of shorter ones which are partly in use between the various German seaports, and between German and neighboring countries. For example, there is a cable 51.57 miles long from Arkona to Trelleborg, Sweden, which has been in use since 1865, and besides these there are three African cables which have been rented from the owners, the different English cable companies. These are as follows: East Africa, Sansibar-Bagamoya-Dar-es-Salaam, 84.5 miles; Southwest Africa, Swakopmund-Mossamedes, 152.3 miles; Kameroon, Boony-Duala of 209.4 miles. Of these the first two belong to the Eastern and South African Telegraph Company, and the last to the African Direct Telegraph Company.

Altogether Germany has over 18,816 miles of cables, of which, however, only about 3,293 miles are owned by the government. The total cable length of the earth is between 273,402 and 279.616 miles, from which will be seen that Germany's percentage is, notwithstanding all the progress which has been made in the last year in that direction, very modest. Really, only about one-fifteenth of the total cable length is German, while England has more than two-thirds. Not more than two years ago Germany's part was no more than one-twentieth, so it is evident that since that time Germany has made great strides forward. The newly-laid cable from Shanghai to Yap is especially remarkable for the reason that a continuous line of cable has been laid around the whole earth which is not English.

From Europe to east Asia and to the Chinese coast there are the land telegraphs and sea cables of the Danish Great Norse Telegraph Company. The Atlantic Ocean is traversed not only by the English telegraph lines but also by the American, French, and German cables. These are, through the various service lines of the United States, combined with the western coast of America, and from San Francisco the American Pacific cable extends *via* Guam to the Philippines. In Guam, however, the German-Netherlands cable system branches off to Yap, from which place the new cable has made a new bond of union with the German and Danish lines on the Chinese coast. The cable Shanghai-Yap assures to Germany, henceforth, a telegraphic union with the Ladrone and Caroline Islands independent of English influence, and these islands are German colonial possessions, besides also the union with the Great Sunda islands and the important Dutch colonial posessions in Farther India, which are so important also for the German commerce.

The Shanghai-Yap cable line has been laid in greater sea depths than any other cable. Up to a few years ago there was no cable in a greater ocean depth than 16,404 feet. The American cable in the Pacific Ocean was in 1903 laid in depths to 20,469 feet. The cable Menado-Yap-Guam, which was laid in the year 1905 by the German cable steamer "Stephan," surpassed this record, inasmuch as it was obliged to lay the cable in depths of 22,966 feet, and to lay the cable Shanghai-Yap, which work was also the task of the cable steamer "Stephan." It was even necessary in the vicinity of Liukin islands to reach depths of 26,246.96 feet, which is one of the deepest places to be found anywhere in the oceans. The cable was manufactured in Germany by the North German Sea-Cable Works in Nordenham at the mouth of the Weser.

ELECTRO-TECHNICAL INDUSTRIES.

THE complete revolutionizing of many old industries, and the creation of entirely new ones, by electricity in the last half dozen years represent some of the most marvelous achievements of the present century. In no line of scientific and experimental work are the uncertain opportunities for magnificent possibilities so brilliant as in the practical laboratory of the electrical engineer and chemist. Electricity supplied in large and cheap current permits the experimenters to make tests in the fusing of metals, which a dozen years ago could not be performed except at enormous cost in time and money.

Electro-metallurgy has given a tremendous impetus to the manufacture and refining of many common articles of commerce, and owing to the cheapening of their manufacture, the demand for them has enormously increased. Thus in the production of aluminium the price has been so reduced in the last few years that it is employed in many new industries. The most noticeable field of usefulness is the substitution of aluminium transmission wires for copper in the electrical industries. The new transmission lines are of stranded aluminium, and they carry heavy voltage over great distances. The longest transmission line in the world, from Electra to San Francisco, a distance of 154 miles, is composed of stranded aluminium wire, and also the Colgate to Oakland line, a distance of 144 miles. The demand for aluminium is so great, that all the electrical manufacturing companies engaged in its production are extending their plants to increase the output. There are to-day upward of 70,000 electrical horse-power used in the manufacturing of aluminium in this country and Europe. Four plants are located in this country and they have available for the manufacture of aluminium upward of 24,000 horse-power, and the total output of the American plants varies from 15,000 tons upward a year. With the development of the Niagara power the extension of these aluminium manufacturing companies is being rapidly pushed, and the total capacity of the plants is likely to double within a year or two.

In copper refining electricity has achieved results no less notable than in the production of aluminium. There are upward of thirty-two electrolytic copper refineries in operation to-day, and considerably over

half the world's output of copper is refined in these plants. The annual output of electrolytic copper is estimated at nearly 320,000 tons a year. In spite of the cheapening of the refining of copper by electricity, the price has steadily advanced in recent years. The employment of electricity for the extraction of copper from low-grade ores has also developed a good deal, and in this new development it may be possible to materially increase the world's annual supply. In Canada the electrical extraction has been quite successful with ores containing only from 2 to 4 per cent copper. An experimental company of French operators have more recently located a plant in Chili to handle the low-grade native ores of that country by means of an electric furnace process of concentration. The recovery and refining of scrap copper has also assumed considerable proportions in this country. By means of the electrolytic process, old copper bottoms, boilers, tubing, nails, sheet clippings, and type-shells can be utilized in a remarkable way. Scrap copper of this nature commands from 12 to 13 cents a pound, and is only a trifle less than casting copper. The scrap copper is thus recovered at little cost, and used over again in the industries. Old copper wire commands a premium to-day at prices ranging from a cent to half a cent less than that of the best casting copper.

The manufacture of artificial graphite with the electric furnace has assumed considerable importance, and to-day upward of 3,000 horse-power is used in supplying the electric furnaces with heat for this purpose. The output of artificial graphite at Niagara Falls last year was over three million pounds. The method of production is covered by patents, but the process consists of converting a large mass of coke or carbon into graphite by means of the electric furnace. At a certain temperature all carbides decompose, and the carbon separates in the form of graphite, but by the process now used only a small amount of iron or silicon is required for the purpose. The flourishing nature of this industry has led to further extensive experiments with the electric furnace in the treatment of carbides.

The use of the electric furnace in the iron and steel industry has promised for several years great transformation of smelting, but the actual reduction of iron ore for steel making by means of the electric furnace has not yet attained a large commercial success. A number of such furnaces have been in operation in different parts of the country, and new improvements are constantly being made to simplify the process. In certain parts of the world where electric current is very cheap and abundant, iron ore plentiful, and coal scarce and high priced, the electric furnace may displace the ordinary blast furnace for the production of pig iron. Or what may be nearer the truth, the use of the electric furnace in certain regions near great hydraulic works may build up electric smelting where it would be impossible to succeed with coal as a fuel.

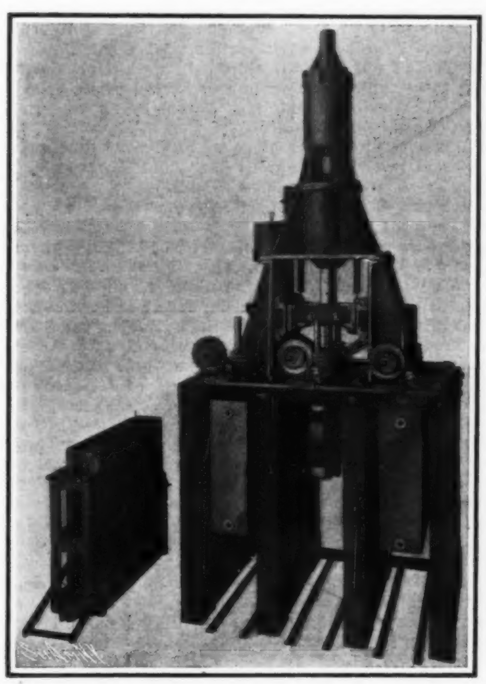
In the specialized field of making high-class steels and steel alloys from scrap, the electric furnace has a more promising outlook, and quite remarkable achievements have already been made. Both in Germany and France such electric furnaces for steel making have been in profitable use the past year. In France at Le Praz, in Savoy, a plant for steel making utilizes the Heroult furnace, in which the electric arc is employed for heating, and at a cost of 6.5 cents per ton for electrical energy between six and ten tons of specialized steel are produced daily at a good profit. Over 5,000 tons of steel have been produced at this plant. Two other plants are in successful operation in France, one of which uses the arc for heating and the other the resistance method. In Italy the Stessam electric furnace is employed extensively, and in Germany similar attempts at steel making by the electric method are being carried on with more or less success.

In this country and Canada the electric steel furnace is in operation experimentally. At Massena a new process in which a patented electric furnace is employed has been tried, and the project promises much for the future. At Niagara Falls, the Ruthenberg process is also in use, but not commercially. A number of other plants, using either the Heroult or Keller furnace, have been established, but so far most of them are making tests for future commercial exploitation.

In the manufacture of such alloys of iron as ferrochrome, ferro-silicon, and ferro-titanium by the electric furnace, a great commercial success has been attained. At Niagara Falls ferro-titanium is made in the electric furnace from scrap iron, aluminium, and cheap titaniferous iron ore. Even discarded slag is utilized. Likewise ferro-silicon is made from scrap iron and scrap steel. A good many of the old carbide works which failed have been rebuilt for manufacturing ferro-silicon. The resistance type of furnace is employed for this work, and the scrap iron or steel is melted at a high temperature with pure quartz. A 4,000-horse-power plant generally turns out about 20 tons of this alloy a day. Ferro-chrome is an alloy used in the manufacture of face-hardened steel, especially for armor plates and tools. One plant turns out upward of 1,800 tons per year for the Carnegie and Bethlehem steel companies. The electric furnace employed for this manufacture is not materially different from those used in allied industries. Ferromanganese is made in the electric furnace for the steel industry on a smaller scale, but it has become an important factor in modern production of high-grade steels.

The question of using the electric furnace in glass manufacture has received unusual attention the past year, and it is predicted that a complete revolution may be thus created in this industry thereby. If the electric furnace should prove as successful as promised in this field, it would probably mean the shifting of the center of manufacturing from Pittsburg to Niagara Falls or some similar place where electric current can be had cheaply and in abundance. It is not likely for some time to come that the electric furnace can displace the regenerative gas furnace for glass making except in a few favored regions. However, in Germany electric glass furnaces are being used, especially in the production of quartz glass vessels for chemical purposes. The quartz-glass manufacture has assumed a good deal of popularity in many new lines of work, for the glass is not easily fractured by sudden changes of temperature, and its melting point is very high. In regions where quartz exists in great quantities, and water power for electrical development is favorable, the manufacture of quartz-glass vessels and articles in the electrical furnace appears to have a very promising future. Experiments are now being conducted by a number of companies along this line, and only the future can determine what ultimate effect the electric current will have upon the glass trade.

In bullion refining, electricity has made great strides. Electrolytic methods of refining gold and silver are employed in all parts of the world. At Perth Amboy and Philadelphia large quantities of the two precious metals are thus refined. In Germany the electric refining of gold and silver is carried on even more extensively, and the combined outputs of the Frankfort and Hamburg refineries are valued at a good deal over ten million dollars a year. The electrolytic method of bullion refining, however, is increasing rapidly in this country, and as one of the largest producers of precious metals in the world, it seems not unlikely that we shall stand first in this industry of refining within a few years.



THE FERRANTI THREE-PHASE CONTROL SWITCH.

Electro-metallurgical industries include the manufacture of many other products of only slightly less importance than those mentioned. Such new products as silicon-copper and siloxicon are the results of the application of the electric furnace to experimental fields. Nickel, lead, tin, and zinc have all come under the power of electricity, and they are either refined or extracted from the ore by electrical methods in increasing quantity. Not the least important of these methods is the recovery of scrap. Scrap tin and zinc are recovered to-day by electrolytic processes, which make every tin can, tin roof, or tin boiler of potential value. Electricity has made phenomenal strides in saving the waste. Metal of any kind can be reconverted by it into useful material for new manufacture. In other words, the scrap heap and waste pile are as legitimate a field of exploitation for electricity as the mines with their rich or low-grade ores.

THE FERRANTI NEW THREE-PHASE REMOTE-CONTROL OIL-SWITCH.

By the English Correspondent of SCIENTIFIC AMERICAN.

A NEW type of oil switch has been devised by Mr. Ferranti, of the firm of Ferranti, Limited, of Hollinwood, Lancashire, who first intoduced the practice of breaking electrical circuits in oil as far back as 1894, in conjunction with Mr. M. B. Field. The oil breaking system as originally devised by Mr. Ferranti is now universally adopted, as its merits and efficiency have been generally recognized. When the idea was adopted it was quickly reduced to a standard form, and although there is a wide divergence in the operating mechanism of the types produced by various manufacturers, the fundamental principle is the same.

In this latest development, which is designed for large installations, the switch is carried upon four concrete walls, each about 4 inches in thickness, which constitute the foundation for the metal framework and at the same time serve the purpose of dividing the phases. The framing comprises four brackets which extend upward and which are cast solid with the base plate. This framing is machined to serve as guides for the moving parts and at the same time to support the electrical mechanism carried above. There is a cross-head fitted with rollers which travels between these guides and to this are attached three vertical rods which pass through the base plate. Each rod carries with a porcelain sleeve the bridging piece and the movable contacts for its particular phase. To close the switch the cross-head is raised, this action bringing the bridge pieces into contact with the fixed contacts carried by the framing. There are two iron-clad solenoids placed in tandem in order to close the switch, the pull of these solenoids acting directly upon the cross-heads so that the employment of intermediate levers or any other complication is dispensed with.

The action of the plungers is contrived in an ingenious manner, and has been designed by Mr. M. B. Field. The lower plunger is fixed rigidly to the cross-head and when the switch is open, it is almost outside its solenoid. The upper plunger slides on a vertical rod which is a continuation of the lower one, and the switch when open enables the plunger to rest upon the cover of the lower casing, so that it is in a convenient position to be acted upon by the upper solenoid. The cross-head in descending causes the central rod to slide through the upper plunger, bringing the collar at the top of the rod to rest upon the upper surface of the plunger. Both solenoids are simultaneously excited at the same moment, but owing to the more advantageous position of the upper plunger within the coil, the upper solenoid does the most work at the beginning of the stroke. The upper plunger completes its travel at the time the stroke is half finished, but at this point the lower plunger has been brought well within the field of its solenoid and consequently takes up the work, the central rod then sliding idly through the upper plunger. A very strong and long pull is available by means of this arrangement, which has a travel of 10 inches with an initial pull of 180 pounds and a final pull of 400 pounds.

Attached to the cross-head at the side of the lower solenoid are two springs, and these are so designed that when the switch is closed they are unextended, but when opened they exert a lifting force approximating 75 per cent of the weight to be raised. These springs fulfill a dual purpose. Being extended when the switch is opened the closing motion of the latter is greatly accelerated thereby, while when it is desired to open the switch, though they do not retard the rapidity of the breaking of the circuit, they serve to absorb the shock and jar when the switch has reached the fully open position. There are also two other short and stiff springs placed on the top side of the plungers. The rapid increase in the effective force of the solenoids during the last part of the stroke compresses these springs, thereby providing an appreciable aid to the initial acceleration during the opening motion of the switch, more especially at that point when the friction of the main switch contacts has to be overcome.

To overcome all sideway thrust against the frame and to prevent undue pressure being brought to bear upon the guide rollers when operating the switch, a system of toggle joints is adopted. There are eight links arranged diamond fashion which are fixed to the cast-iron top plate below and the moving cross-head above, together with a trigger pivoted on the right-hand hinge pin and catches on the left-hand hinge pin. The links open out laterally when the switch is opened, but the trigger remains in a practically horizontal position. When the switch is closed the links are brought nearly vertical and the switch is kept so by means of the trigger. The end of the trigger is acted upon by the plunger of a trip coil, there being a certain amount of free play provided so that when the switch is tripped the trigger receives a hammer blow. The trigger also provides an alternative method of operating the mechanism independently of any electrical source, since by raising the end of the trigger the switch is tripped.

Flexibly suspended jaws are provided to the fixed contacts so that the whole surface makes uniform and efficient contact. The length of each break is 9 inches, so that the total interruption on each phase is 18 inches. As the switch opens each tank is divided into two separate compartments by means of insulating slabs which descend into the oil contemporaneously with the opening of the switch so that arcing under the oil is absolutely prevented. This arrangement, it may be pointed out, constitutes a notable feature of the mechanism. There is a complete insulating lining of the tanks. There is a space of ⅜ inch between the lining and cast iron containing oil which remains quiescent no matter how much the main volume of oil may be disturbed by the arc at the descent of the contact bridge. There is a special carrier provided with wheels to run the tank into its cubicle where it is raised either by ratchet mechanism on the bed plate or by means of a lever.

In remote control switches it is imperative to prevent possible disaster. Therefore the possibilities of failure should be completely prevented, and for this purpose complications in the mechanism and its control must be avoided. This switch is both simple in construction and easy of operation. In order to close the switch the operator first gives half a revolution to a small handwheel on the control board. Pressure on a small lever then energizes the solenoids and the

switch is instantly closed. The switch is positive in its action, i. e., once the small lever has been depressed the switch must close so that it is impossible for the operator to cause any damage either from hesitation in closing the switch, or changing his mind during the operation, while furthermore the two motions necessary to carry out the operation successfully guard against the liability of the switch being closed inadvertently. On the control board are carried signal lamps operated by the switch itself which indicate whether the main circuit is open or closed.

CONTEMPORARY ELECTRICAL SCIENCE.*

Ions in Colored Flames.—MacClelland has shown that the ions in colorless flames have velocities ranging from 0.53 centimeter per second at 230 deg. to 0.9 centimeter per second at 105 deg. Now, the rate of discharge of an electroscope brought near a Bunsen flame is greatly reduced when the salt of an alkali metal is introduced into it. Since in this case the ionization of the flame is considerably increased, it is natural to conclude that the ionic velocities are much smaller in the colored than in the colorless flame. The ionization is known to be increased about twenty times by blowing a spray of a saturated NaCl solution into the flame. Now, the author finds that the velocity of the ions in the colored flame is about fifty times less, so that the difference of conductivity is accounted for, the current being proportional both to the number of ions and their velocity. All alkali metals furnish ions of nearly the same velocity. The velocities of ions of the alkaline earths are a little less than half that. The negative ions have a velocity slightly exceeding that of the positive ions, but in all cases the ionic velocity varies inversely as the square root of the concentration. The real concentration of the salt in the flame is, of course, an unknown quantity.—P. Lewis, Physikalische Zeitschrift, October 26, 1905.

Ionization by α-Particles.—Rutherford recently announced that the α-particle projected from radium ceases ionizing when its velocity falls below 60 per cent of its velocity of projection, when, therefore, it still possesses a velocity of 1.6×10^{10} centimeter per second. Bragg and Kleeman thought, on the other hand, that the velocity becomes almost negligible before the ionization ceases. W. H. Bragg now reviews the results which formed the basis of that opinion, and finds that whatever the critical velocity may be, it is the same in all gases. The ionization curve was examined in many gases, including gases of complex molecular structure, as well as mixed gases. Now, if the α-particle were able to ionize in, say, hydrogen at a lower speed than in oxygen or carbon, the ionization curve in a mixture should be a complex curve, consisting of simple curves overlapping. The entire absence of any effect of this kind shows that the critical speed is invariable. This makes it probable that the act of ionization is exactly the same in all gases. The author next proceeds to find in what manner the ionization depends upon the speed, and constructs tables showing the observed ionizations and the corresponding values obtained from a formula in which the ionization is made to vary inversely as the nth power of the velocity. The values 1, 2, and 3 are given to n in three separate columns, and it is evident that $n = 2$ gives the best agreement. This may be connected with the fact that when one particle flies at great speed past another which is relatively at rest, the energy given by the ionizing to the stationary particle, in consequence of their mutual attractions or repulsions, is inversely proportional to the square of the velocity of the moving particle.—W. H. Bragg, Philosophical Magazine, November, 1905.

Emission of Electrons by Alkali Metals.—Elster and Geitel announced long ago that the alkali metals when exposed to light give out electrons, even when the light is of very feeble intensity. A piece of glass rod heated to a dull red heat is sufficient to make rubidium emit corpuscles. But J. J. Thomson has now found that there is a small emission of electrons even when all external light is excluded. The electroscope was mounted in a vacuum over rubidium or an alloy of potassium and sodium in an exceedingly low vacuum. It was read by red light, which produced but a slight leak. When the leaves of the electroscope were charged with positive electricity there was always a small leak of electricity from the leaves, while there was no perceptible leak when the leaves were negatively charged. The positive leak was entirely stopped by a transverse magnetic field. This proves that it is due to negative electrons emitted by the metal. The presence of a small quantity of fresh hydrogen considerably increases the production of electrons, owing to its simultaneous absorption by the metal. The alkali metals also give off electrons when in the gaseous state. The atoms then become positively charged, and deposit themselves by preference on a negatively-charged surface. The author concludes that the alkali metals are in reality radio-active, and, like other radio-active bodies, give off slow β-rays. But in contradistinction to them, the evolving of these slow electrons is to a certain extent under our control, being influenced by light, heat, and chemical forces. These act as detonators, and split up atoms which have become unstable. This process probably goes on in all matter. If it goes on in the whole earth, the emission by every atom of an electron once in a thousand million years would be sufficient to account for the earth's internal heat. The "fatigue" of platinum and other substances after prolonged incandescence may be due to such an atomic modification.—J. J. Thomson, Philosophical Magazine, November, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

THE EFFECT UPON FISHES OF SUPERAERATED WATER.

Under normal conditions fishes live in water which contains no more dissolved air than may be absorbed spontaneously at atmospheric pressure and the prevailing temperature. As the nitrogen and oxygen of the atmosphere are not very soluble in water, the maximum amount dissolved at 0 deg. C. and 760 millimeters Hg is not large, being 19.53 cubic centimeters per liter of the former gas and 10.18 cubic centimeters per liter of the latter. When these amounts are exceeded, or when the corresponding content for any particular temperature and pressure is exceeded, the water is supersaturated, and while it remains in this condition it may cause remarkable symptoms upon fishes which often result fatally. An investigation of the subject has been conducted by Prof. F. P. Gorham and the author for the United States Bureau of Fisheries, and results obtained are here briefly summarized.

As the station of the United States Bureau of Fisheries at Wood's Hole, Mass., an instance of sea water with an excess of air occurred. This was due primarily to a leaky suction pipe which allowed air to enter it and pass with the water to the steam pump which lifted the water to storage tanks about 18 feet high. Having passed through the pump, this mixture of water and air became subjected to a hydrostatic pressure of about 8 pounds, which forced the air into solution. From the storage tanks the water flowed to aquaria and being again at atmospheric pressure was in a condition of supersaturation with air. Air constantly escaped from it, both by separation in bubbles upon the sides of the aquaria and by escape at the surface. The constant flow, nevertheless, maintained the supersaturation. The fishes showed a variety of symptoms. There was first a precipitation of very minute bubbles upon their bodies and fins, completely covering them. After a longer time blisters of gas formed in the skin, chiefly of the fins, and sometimes became so large as to buoy the fish so that it could scarcely keep below the surface. With some species the eyeball was partially extruded from the head, causing the symptom known among fish-culturists as pop-eye. This exophthalmia was caused by an accumulation of gas behind the eye.

Death resulted after a longer or shorter time. The external gas did no serious harm, but death was due to free gas within the blood vessels—to gas embolism. Often the vessels of the gill-filaments were filled with gas, and the ventral aorta and bulbus of the heart distended with it and quite empty of blood. This gas was about 97 per cent nitrogen.

The water itself, when the dissolved air was determined, was found to contain an excess of both oxygen and nitrogen. By controlling the amount of air which entered the suction different degrees of excess could be produced. On one occasion the water at 10.5 deg. C. contained 18.79 cubic centimeters of nitrogen per liter, an excess of about 6.4 cubic centimeters; and 8.41 cubic centimeters of oxygen, an excess of 2 cubic centimeters per liter. This water was fatal to hake within 8 to 20 hours, and it is probable that no fish could long survive in it. When the excess was not so great, a longer time was required to kill. A supersaturation of about 2 cubic centimeters of nitrogen per liter of water is sufficient to cause symptoms upon some species, but with less than this fishes may live perhaps indefinitely though there is probably some functional disturbance.

The gas which is chiefly or entirely responsible for the symptoms and fatalities is nitrogen alone. Natural waters are not infrequently air-supersaturated with nitrogen at their origin, and this condition is usually accompanied by a deficiency of oxygen. Substantially the same results may be brought about by such water as by that described above. In either case the water may be corrected by thoroughly exposing it to the air, which removes the excess of the one gas and supplies the deficiency of the other. The exposure must be very intimate, however, and requires that the water be broken up into slender streams, as by passing through a bottom with many small perforations; or by dividing into thin sheets. Two and one-half gallons of supersaturated sea water in a cylindrical open vessel required more than two days to discharge spontaneously its excess of air. The presence of the free gas within the blood vessels is to be explained as a precipitation from the blood due to a rise in temperature. The high osmotic pressure of the air dissolved in the water forces unusual amounts of air into solution in the blood by way of the gills. After leaving the gills the blood is warmed slightly by the oxidation processes, and the difference in temperature between the water and the blood in the heart amounts in some cases to several degrees Fahrenheit. Thus the blood slowly releases some of its dissolved air—more strictly its dissolved nitrogen—which accumulates until a stasis of the circulation occurs, and consequently the death of the fish. A marked analogy exists between this affection and the caisson disease in man. In the latter the body sustains an actual increase of pressure which is subsequently removed and the symptoms follow. This change of pressure has no counterpart among fishes, save that the origin of the supersaturation is referable to an increase of pressure. Fishes may suffer the disease without necessarily undergoing any change whatever in the hydrostatic pressure which they sustain. The analogy lies in the supersaturation of the blood which occurs in both man and fishes. In deaths among caisson workers, free gas is often found in the blood vessels. A rapid decompression of course favors the precipitation of gas and the precautions for avoiding harmful results include a gradual reduction of the pressure to normal.

An increase of pressure may be used to prevent the gas symptoms among fishes. If water supersaturated with air is subjected to a sufficient increase of pressure the supersaturation no longer exists, though the actual amount of dissolved air may not be changed. In such water the saturation point of the blood and other fluids of the fish, as well as of the water itself, is raised and while the increase of pressure remains the fish will suffer no harm from superaeration.

ACOUSTICS: ITS HISTORY IN BRIEF.

Early in the nineteenth century the velocity of sound given in a famous equation of Newton was corrected to agree with observation by Laplace (1816).

The great problems in acoustics are addressed in part to the elastician, in part to the physiologist. In the former case the work of Rayleigh (1877) has described the present stage of development, interpreting and enriching almost every part discussed. In the latter case Helmholtz (1863) has devoted his immense powers to a like purpose and with like success. König has been prominently concerned with the construction of accurate acoustic apparatus.

It is interesting to note that the differential equation representing the vibration of strings was the first to be integrated; that it passed from D'Alembert (1747) successively to Euler (1779), Bernoulli (1753) and Lagrange (1759). With the introduction of Fourier's series (1807) and of spherical harmonics at the very beginning of the century, D'Alembert's and the other corresponding equations in acoustics readily yielded to rigorous analysis. Rayleigh's first six chapters summarize the results for one and for two degrees of freedom.

Flexural vibration in rods, membranes, and plates become prominent in the unique investigations of Chladni (1787, 1796, "Akustik," 1802). The behavior of vibrating rods has been developed by Euler (1779), Cauchy (1827), Poisson (1833), Strehike (1833), Lissajous (1833), Seebeck (1849), and is summarized in the seventh and eighth chapters of Rayleigh's book. The transverse vibration of membranes engaged the attention of Poisson (1829). Round membranes were rigorously treated by Kirchhoff (1850) and by Clebsch (1862); elliptic membranes by Mathieu (1868). The problem of vibrating plates presents formidable difficulties resulting not only from the edge conditions, but from the underlying differential equation of the fourth degree due to Sophie Germain (1810) and to Lagrange (1811). The solutions have taxed the powers of Poisson (1812, 1829), Cauchy (1829), Kirchhoff (1850), Boussinesq (1871-79) and others. For the circular plate Kirchhoff gave the complete theory. Rayleigh systematized the results for the quadratic plate and the general account makes up his ninth and tenth chapters.

Longitudinal vibrations which are of particular importance in case of the organ pipe, were considered in succession by Poisson (1817), Hopkins (1838), Quet (1855); but Helmholtz in his famous paper of 1860 gave the first adequate theory of the open organ pipe, involving viscosity. Further extension was then added by Kirchhoff (1868), and by Rayleigh (1870, *et seq.*), including particularly powerful analysis of resonance. The subject in its entirety, including the allied treatment of the resonator, completes the second volume of Rayleigh's "Sound."

On the other hand, the whole subject of tone quality, of combination and difference tones, of speech, of harmony, in its physical, physiological, and esthetic relations, has been reconstructed, using all the work of earlier investigators by Helmholtz (1862), in his masterly "Tonempfindungen." With rare skill and devotion König contributed a wealth of siren-like experimental appurtenances.

Acousticians have been fertile in devising ingenious methods and apparatus, among which the tuning fork with resonator of Marloye, the siren of Cagniard de le Tour (1819), the Lissajous curves (1857), the stroboscope of Plateau (1832), the manometric flames of König (1862, 1872), the dust methods of Chladni (1787), and of Kundt (1865-68), Melde's vibrating strings (1860, 1864), the phonograph of Edison and of Bell (1877), are among the more famous.

THE DEVELOPMENT OF THE CONCEPTION OF CAPILLARITY.

Capillarity antedated the nineteenth century in little more than the provisional, though brilliant, treatment due to Clairaut (1743). The theory arose in almost its present state of perfection in the great memoir of Laplace (1805), one of the most beautiful examples of the Newton-Boscovichian (1758) molecular dynamics. Capillary pressure was here shown to vary with the principal radii of curvature of the exposed surface, in an equation involving two constants, one dependent on the liquid only, the other doubly specific for the bodies in contact. Integrations for special conditions include the cases of tubes, plates, drops, contact angle, and similar instances. Gauss (1829), dissatisfied with Laplace's method, virtually reproduced the whole theory from a new basis, avoiding molecular forces in favor of Lagrangian displacements, while Poisson (1831) obtained Laplace's equations by actually accentuating the molecular hypothesis; but his demonstration has since been discredited. Young in 1805 explained capillary phenomena by postulating a constant surface tension, a method which has since been popularized by Maxwell ("Heat," 1872).

With these magnificent theories propounded for guidance at the very threshold of the century, one is prepared to anticipate the wealth of experimental and of detailed theoretical research which has been devoted

to capillarity. Among these the fascinating monograph of Plateau (1873), in which the consequences of theory are tested by the behavior both of liquid lamellæ, and by suspended masses, Savart's (1833), and particularly Rayleigh's, researches with jets (1879-83), Kelvin's ripples (1871), may be cited as typical. Of peculiar importance, quite apart from its meteorological bearing, is Kelvin's deduction (1870) of the interdependence of surface tension and vapor pressure when varying with the curvature of a droplet.

ENGINEERING NOTES.

The development of locomotive tractive effort during the past ten years was made necessary owing to the inauguration of high steam pressures and large cylinders. The increased power produced in the cylinders has transmitted stresses to the cylinders themselves, as well as to the connecting frames, which has resulted in an increased number of breakages and failures of these parts. This, together with the preference that has been given to the movement of tonnage without consideration of speed, has contributed largely to the low average modern locomotive mileage and the high costs for maintenance and operation.

In the variable-speed steam turbine designed by W. J. A. London, a description of which is published in the Mechanical Engineer, the steam admission belt is divided into eight chambers, the alternate four forming one of two sets, each of which has a steam inlet common to the four, both steam inlets being controlled by a valve. The steam passing into either set, goes through the corresponding nozzles into the same primary set of a number of moving blades and fixed vanes. In the case of one group of chambers the steam passes direct from the primary set of blading to the exhaust chamber, but when it is passed into the other set of chambers it must traverse an additional or secondary set of blading before reaching the exhaust passage, and thus will cause the turbine drum to revolve at a less speed.

The Memmo process for oxy-acetylene welding which is one of the most recent of the Continental methods, is based upon the use of a mixture of two volumes of oxygen and one of acetylene. The flame which is formed by the two gases has a blue inner core surrounded by a very hot colorless zone. If the acetylene is in excess, the flame is luminous, and we must regulate the inlet of gas so that it is colorless. If the oxygen is in excess, the flame goes out very easily. In the new process, the temperature goes as high as 3,800 or 4,000 deg. C. in place of 3,500 deg., which the oxygen flame will give. The price of 30 cubic feet of acetylene is about 30 cents, and for the same quantity of oxygen, 60 cents, so that for the two we have about 90 cents. The two gases are brought in very fine tubes under a pressure of 0.1 to 0.15 atmosphere into a T-tube in which they are mixed. The acetylene tank should have a check-valve to prevent the oxygen from entering. As to the length of the flame it is about two-thirds of an inch and the diameter is from 0.12 to 0.15 inch. In the oxy-acetylene flame we can easily melt platinum and like bodies, and the inventor claims that the new process gives a very good weld for metals.

The experiments to determine the loss of heat through furnace walls, conducted by J. Bied, says the Rev. de Métallurgie, consisted in placing boxes of galvanized sheet having about 2,500 square centimeters (400 square inches) of surface and about 1½ inches water space, against the walls of furnaces, gas producers, and gas flues, ascertaining the furnace temperature and the weight and temperature of water passed through the box in a given time. The loss of heat in calories per square meter of wall surface per hour, ascertained in different experiments with different thicknesses of walls, is given in the following table:

Nature and thickness of walls.	Interior temperature. Deg. C.	Loss of heat.
Alumina brick, 14 cm. (5½ in.), with	500	1,600
coating of magnesia carbonate, 5 cm.	700	2,208
(2 in.)	700	2,506
The above wall with an addition of finely ground slag, 20 cm. (7⅞ in.), and cement, 3 cm. (1¼ in.)........	700	526
Kieselguhr lightly compressed, 5 cm..	650	1,801
Alumina brick, 20 cm................	700	2,570
Alumina brick, 20 cm., with 20 cm. ground slag	700	900
Magnesia brick, 45 cm., with coating of magnesium carbonate, 6 cm., and ordinary fire-brick, 80 cm..........	1,300	1,301
Magnesia brick, 45 cm., magnesium carbonate, 6 cm., and ordinary fire-brick, 80 cm.	1,600	1,900

The discovery of the value of certain steel alloys is one of the greatest of the age in regard to machine-shop practice. Its value is far-reaching, not only in greatly decreasing the time required for an operation, but also in leading machine-shop men to investigate all connecting problems, such as the strength and better design of machines, the time required for handling and chucking the work, etc. If, under old conditions, a certain operation in a machine required three hours' time and one hour for chucking and handling, the idle time of the machine would be only 25 per cent of the total; if the time of the operation were reduced by the use of high-speed steels to one hour, then the idle time would be 50 per cent, and some endeavor would undoubtedly be made to decrease time of chucking. There is a large amount of literature on the subject of these high-speed steels, and some of the showings are little short of marvelous compared with former practice. This is especially the case under favorable conditions in experimental demonstrations. Under ordinary conditions the results are less startling for the problem is not one of speed alone. High-speed steel may not always be a paying investment; for example, a light job requiring relatively little time for cutting compared to time required for preparing and chucking; or, again, suppose, under ordinary conditions, a man has all he can do attending to two machines, the cutting time of one being just sufficient for the chucking time on the other, then any decrease in cutting time would be of small advantage. In general, the new steels cannot be used to the limit; first, because the present machines will not stand it and the general tendency is to retain present tools, working them to the limit instead of at once scrapping them, and, second, much of the work will not stand it on account of special shapes. The old carbon steels give better results, as far as service is concerned, on very light finishing cuts. But on the larger work, shafting, guns, wheel turning, big planing operations, etc., the advantage is enormous. These steels have increased the output of railroad-shop machines 25 to 100 per cent, and in some cases even 200 per cent. There is still considerable experimental data to be obtained before the best results are obtainable from these steels, as the speed bears some relation to the depth of cut and the feed. The highest speed does not necessarily remove the greatest amount of metal in a given time. In general, a slower speed and heavier cut and feed are more efficient.

ELECTRICAL NOTES.

The Allgemeine Gesellschaft, of Berlin, has brought out a considerable improvement in the manufacture of Nernst lamps. It has been able to change the method of construction of the 200 to 300 volt lamps so that the price of the burner is reduced to 17 cents. This has been carried out according to the principle that a great portion of the heating device only serves to diminish the tension and has no effect in the heating proper. Thus it reduces the luminous effect to a great degree. The burner is made much smaller by using a resistance coil placed in the lamp to cut down the tension. In this way the burner is reduced to one-third of its former weight. The new burner which is adapted for the B-1905 type of Nernst lamp does not cost any more than a carbon-filament incandescent lamp. It reduces the current consumption to 0.25 ampere at a tension of 200 to 300 volts.

A new incombustible insulating material has been recently brought out by a Berlin electrical firm which is claimed to be a great step in advance. At present the substances which replace ebonite are quite combustible and take fire at a low temperature. Other substances which are incombustible have but a low electrical insulation, and can be easily perforated by the spark. Most of them readily absorb moisture. Porcelain, which is about the only body having insulating and refractory properties, cannot be easily worked. In the present state of the electrical industry it would be a great advantage to find a substance which fills all the desired points. After many researches the Allgemeine Company claim to have found a composition which is formed by the mechanical union of a good insulating substance, and another fireproof substance, and the properties of both are kept without destroying the homogeneous texture of the whole. In practice they use a good insulating compound and upon it are applied layers of an incombustible substance such as asbestos, by a high pressure. Plates of such a nature are formed, with the outer part fireproof, and the inner part a good insulator. Sometimes the fireproof coating can be put upon one side only. Different forms can be given to the new composition.

The Accumulator Company, of Cologne, has taken up the construction of storage batteries of the Jungner-Edison type, and now holds the German patents of the Jungner cell. Their process contains a number of improvements. For the material of the positive plate they use a green hydrate of nickel obtained by an electrolytic process and this is transformed by chemical oxydation into the black hydrate. To prepare the negative plate, finely divided and reduced iron is used which is obtained by reducing iron scale. To give a good conductivity the nickel is mixed with 40 per cent of graphite. The mass of iron is mixed with 10 per cent of graphite. The graphite has been coated with nickel by electrolysis. The masses are then compressed at a moderate pressure into small briquettes tablets of 1/6 inch thickness, and measuring 3.4 by 0.7 inches. These tablets are introduced into pockets formed in a thin sheet of pure nickel, and are then placed under the hydraulic press. One plate contains ten of these pockets. The plates carry a set of grooves so as to allow the gases which form during the charging to escape. The battery which measures 12 by 3.8 by 2 inches is formed of six pairs of plates, and when in the sheet steel case it weighs about 6.6 pounds. Up to the present they have not been able to obtain steel cases of a single piece which are less than 1/25 inch thick. Using iron cases which are but 0.012 inch thick, the total weight of the cell is reduced to 6 pounds. For the electrolyte they use a 20 per cent alkaline solution which is free from acid radicals, organic substances and carbonic acid as nearly as possible. The tension on open circuit is 1.35 volt. The new cells have not as yet been put through a sufficient test. The nickel electrodes seem to act very well, while the iron electrodes are not as satisfactory. In the tests made after 100 discharges, they had lost 12 per cent of their initial capacity, and after 200 discharges, 17 per cent.

SCIENCE NOTES.

The fundamental idea in the theory of natural selection is the persistence of those types of life which are adapted to their surrounding conditions, and the elimination by extermination of ill-adapted types. The struggle for life among forms possessing a greater or less degree of adaptation to slowly varying conditions is held to explain the gradual transmutation of species. Although a different phraseology is used when we speak of the physical world, yet the idea is essentially the same.

The foundation of modern medicine, modern surgery, modern gynecology and obstetrics, as well as of modern hygiene, rests on a knowledge of the properties of certain minute micro-organisms: pathogenic yeasts, pathogenic bacteria, and pathogenic protoza. Preventive medicine is but an intelligent application of this knowledge in the war against infection. Yet, the surprising fact exists, that of the thousands of teachers of elementary physiology and hygiene in the United States, teachers supported by the public purse and required by law to impart this knowledge, practically none are familiar with the simplest elements of bacteriology, practically none have ever received the first rudimentary training in this fundamental subject.

The limit of easy navigation from and to the Red Sea is Sofala. It is not too great a use of imagination to suppose that it would be from information received in what is now north Rhodesia that it was learned that to the westward lay the sea again, and that this led to the attempt to reach it by the south. Once started from the neighborhood of Sofala, they would find themselves in that great oceanic stream, the Agulhas current, which would carry them rapidly to the southern extremity of Africa. Finding themselves in that strong current they were probably alarmed, and attempted to turn back, and after struggling in vain against it they may have accepted the inevitable and gone with it. Without the Agulhas current no such complete voyage of circumnavigation would have been made.

A factor that is often used in the attempt to decide whether or not a water contains an excessive amount of organic matter is the oxygen consumed. The oxygen consumed is not, however, a measure of the organic matter in a water, but only a measure of the amount of mineral reducing salts plus a certain amount of the organic matter, the amount depending on the method of determination used. It gives very little information as to the character of the organic matter, and is only valuable when different surface waters are to be compared with each other, or when used in filtration experiments. The same may be said as regards color, turbidity and the amount of mineral matter that a surface water contains, that, though of essential importance in deciding on the value of a normal water as a potable water, they give little information as to pollution.

Chemistry as a science was a nineteenth century product. There were guesses and ingenious surmises, but there were no known general laws, such as of definite proportions, of atomic weights, of energy in reactions and the like. It became possible to measure approximately the sizes of molecules and atoms, to know definitely their rates of vibration, and molecular structure is, for many compounds, made out about as well as if they could be dissected and their atoms handled like so many parts of an engine or dynamo. As knowledge grew on the basis of experiment, generalization of course was attempted, and as physical phenomena were inextricably interwoven with the chemical, constant modifications were required. Not a few propositions found their way into books and general use which had to be abandoned. Thus, it was assumed that when molecules of salt, NaCl, were dissolved in water, each molecule retained its identity and moved as a whole in the liquid. We now know this is not true, but each atom becomes practically independent and moves like a gaseous particle in the air, producing pressure in the same way, and for the same reason. The new knowledge has made it needful to revise again some of the notions that were held, and so profound is the change required that some years will be needful to bring chemistry as a science into satisfactory relations with physics. That is not all. We have all been taught and have probably had no misgivings in saying that matter is indestructible. Much philosophy is founded on that proposition. But we are now confronted with the well vouched for phenomenon from two independent workers that under certain conditions a certain mass of matter loses weight, not by mechanical removal of some of its molecules, but by the physical changes which take place in it. This is a piece of news that is almost enough to paralyze a scientifically minded man, for stability of atoms, unchanging quantity and quality, seems to be at the basis of logical thinking on almost all matters. In the "Arabian Nights" one may expect that the unexpected will happen—genii may be summoned to do this or that, matter may be created or annihilated at will—and the conception gives one pleasure though one knows it to be impossible, and one thinks it impossible because one has never known such changes in matter, and because one has been taught that matter is indestructible. The amount of change is slight in the experiments related, yet well within the possibility of measuring, and one may be sure that from now on the most expert and careful and patient experimenters will attack this question and verify or disprove it. If it be disproved, we shall be philosophically where we have so long been. If it be proved, it will be the most stunning fact that has come into science for a hundred

years. The nebula theory, the doctrine of evolution, and the antiquity of man will be trifles compared with its significance.

TRADE NOTES AND FORMULÆ.

Jasmine Milk.—To 25 parts of water add gradually, with constant stirring, 1 part of zinc white, 2 liters of grain spirit, and 0.15 to 0.25 part of glycerine; finally stir in 0.07 to 0.10 part of jasmine essence. Filter the mixture and fill into glass bottles. For use as a cosmetic, rub on the raspberry paste on retiring at night, and in the morning use the jasmine milk to remove the paste from the skin. The two work together in their effect.—Pharmaceutische Zeitung.

Aluminium Paper.—Aluminium paper is as yet a novelty. It has been manufactured in Germany for some little time, and is recommended in place of tin foil. This is not, says the Allgemeine Chemische Zeitung, the so-called leaf aluminium, but real paper, glazed with aluminium powder, and is said to have valuable qualities for use in keeping food materials fresh. Chemical analyses show that it contains no arsenic, or other poisonous metal, and very little of any foreign substance, which is an evidence that the aluminium powder used in its manufacture is comparatively pure, containing at the most a little alumina, or aluminium oxide.

The basic material is artificial parchment, coated with a solution of rosin in alcohol or ether. The drying is hastened by a current of air, and the paper is then warmed until the rosin has again softened to a slight degree. The aluminium powder is dusted on and the paper then placed under heavy pressure to face the powder firmly into it. The metallic coating thus formed is not affected by air or greasy substances. Aluminium paper is much cheaper than tin foil, and will prove a serious rival to it, if it does not break easily, and if it will conform to the shape of the articles packed in it.

Preparation of Ammonium Formiate and Ammonia.—According to the Schlutius process, recently introduced in Germany, instead of a mixture of pure nitric oxide and pure hydrogen, a mixture of nitric oxide and hydrogen with other gases is made use of for the preparation of ammonium formiate. These mixtures are exposed to the action of silent electrical discharges in presence of porous substances; for example, platinum sponge. A mixture of this kind consists of the gas obtained by passing air and steam over incandescent masses of anthracite (Dowson gas), the quantitative composition of the gas being about the following: Hydrogen, 14 parts; nitrogen, 43 parts; carbon oxide, 39 parts; carbonic acid, 4 parts. The gas is exposed in presence of steam and platinum sponge, platinized charcoal, or other porous substances susceptible to the action of silent electrical discharges, so that, when there is no cooling of the receiver, formiate of ammonium is produced. Instead of the mixed gas, pure water gas may be employed as an initial product, of which the composition is about the following: Hydrogen, 48 parts; carbon oxide, 46 parts; nitrogen and methane, 6 parts. Pure nitrogen obtained in any manner is mingled. For preparing ammonia instead of ammonium formiate, the heat of reaction disengaged is eliminated by artificial cooling of the receiver in which the reaction takes place. For this purpose the temperature should not exceed 80 deg. C.—Chemik.

Production of Cyanhydric Acid and Cyanides by Means of Sulpho-Cyanides.—By the Tcherniac process, recently introduced in Europe, a small quantity of dilute nitric acid is placed in a receiver of suitable form and heated to about 100 deg. C. The solution of thiocyanide is poured in slowly while a strong current of air traverses the mixture. The proportions of the air with reference to the thiocyanide are so regulated that a little more oxygen enters than is necessary for the equation: $HSCN + O_2 = HCN + SO_2$. If the apparatus in which the oxidation takes place is of sufficient size, a considerable part of the nitric acid employed can, it is said, be regenerated. The gases pass through a column, or other washing arrangement, where they come in contact with water or dilute nitric acid flowing in slowly. The recovery of the nitric acid is accomplished gradually and systematically, and the regenerated acid returns continuously to the oxidizing apparatus. When this is in good working condition, it is sufficient to add from time to time a small quantity of nitric acid for replacing the inevitable loss. The liquid remaining in the apparatus is after a time passed into another receiver, in which air circulates, before entering the apparatus of oxidation. Thus all traces of cyanhydric and nitric acids are volatilized and enter again into the production. The gases which take birth in this reaction contain nitrogen and cyanhydric acid, with an excess of oxygen, steam, and a little carbonic and nitric acids. They are freed from water and nitric acid by suitable absorbents and then directed over alkaline carbonates heated to a dark red color. If carbonate of soda is made use of for the absorption of the cyanhydric acid, the best results are obtained by keeping the temperature at about 450 deg. C., and causing the hydrocyanic gases to pass systematically on the dry and finely-divided carbonate until the conversion is complete. Sodium cyanide, 98-99 per cent. is obtained in the state of powder, which rapidly dissolves in water; it is almost free from cyanate. If carbonate of potash is employed in place of the soda salt, the temperature can be kept a little lower. With calcium carbonate at a higher temperature, calcium cyanamide is obtained.—Rev. des Produits Chimiques.

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